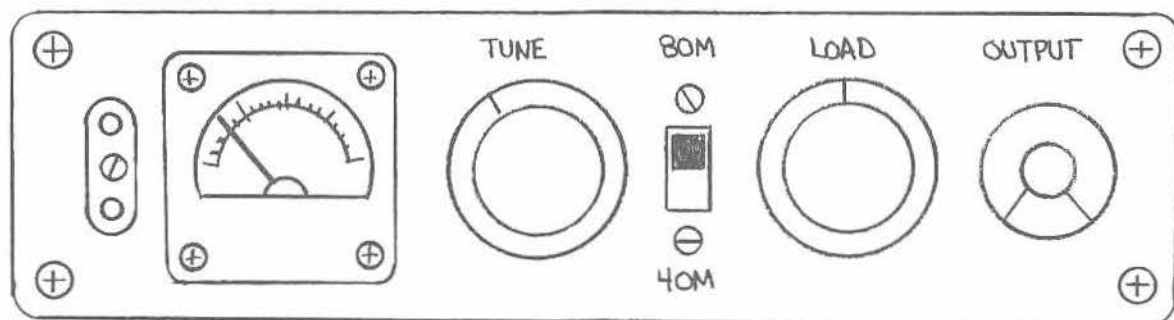


# VINTAGE ANTHOLOGY

## BOOK I



BY DAVID W. ISHMAEL - WA6VVL



VINTAGE ANTHOLOGY

Book 1

A collection of articles written  
for Electric Radio.

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Sitting on top of my favorite vintage receiver, a Collins 75A-4, are three homebrew projects: recycled Heath HG-10 VFO (pg. 108), 6AG7/6E5 80/40M QRP CW xmtr (pg. 47), and 6AG7/1625 5-Band 100W CW xmtr (pg. 66).

To my wife of 30 years  
Judith Ann

A special thanks to Barry and Shirley Wiseman,  
Electric Radio. Without their support and  
encouragement, this book would not have been  
possible.



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- - - WARNING - - -

The high voltages encountered in vintage amateur radio vacuum tube equipment, especially transmitters, can be, at best, potentially dangerous, and at worst, **LETHAL**:

- \* Removing equipment from its cabinet/enclosure for bench-testing, modification, and/or repair, is especially dangerous because the cabinet/enclosure serves as a protective barrier between you and the high voltage.
- \* Do **NOT** depend on front panel pilot lights for primary power status as they can burn out/open.
- \* Do **NOT** depend on the AC switch to disconnect the line voltage from the primary circuitry of the equipment. Play it safe.....unplug it.
- \* After the power has been removed, do **NOT** depend on the "bleeder" resistors to discharge the high voltage filter capacitors. These resistors can open and leave dangerous charges on these capacitors for quite some time. Play it safe.....always discharge these capacitors with an insulated screwdriver or shorting bar.
- \* Homebrew equipment, especially breadboards, can be especially hazardous, because of the limited protection from high voltages. There is **NO** protection from accidental contact with the high voltage w/breadboard units. Plate caps on tubes, especially transmitting types, only exacerbates the problems.
- \* When working around high voltage circuits, keep one hand in your pocket. 100mA flowing through your body can be fatal. Many of the supplies featured in this book can easily meet the 100mA requirement.
- \* A **DANGER HIGH VOLTAGE** label can be placed on the chassis or xfmr or.....to serve as a reminder of the potential danger(s). These labels are available from Seton Name Plate Co. or a number of other sources. Send the author an SASE and he will send you a couple of these labels.

If you are **NOT** accustomed to working around vacuum tube equipment, acquaint yourself with the requisite safety rules **BEFORE** proceeding with any of the projects in this book. The ARRL Handbook is a good source of information - look in the index under **Safety** - **DON'T UNDERESTIMATE THE IMPORTANCE OF SAFETY WHEN WORKING WITH POTENTIALLY FATAL HIGH VOLTAGES.**

The author assumes no liability and is not responsible for accident or injury or financial loss from unsafe practices and techniques utilized in the construction, testing, and/or repair of the equipment featured in this book.

- - - WARNING - - -





- - - THE KNIGHT OCEAN HOPPER - - -

I built my first receiver, an Allied Radio Knight kit Ocean Hopper, in late 1958, and it was not only my first radio, but it was my first kit. It didn't work the first time so my folks returned it to Allied for repair. Allied returned it but I don't remember it ever working. I was 14, two years away from my novice ticket, and really had a lot to learn.



The Allied Radio Knight Kit Ocean Hopper with optional coil set. The Ocean Hopper sold for \$11.75 in 1957. The optional long-wave coil was \$0.79, and the short-wave coils were \$0.65 each. By 1966, the price had increased to \$15.95 and the optional coil set was \$3.49.

I wanted to buy the Space Spanner but at \$17.95 it was too expensive!! The Ocean Hopper at \$13.95 was all I could afford. Even then, I only had the original broadcast band coil. I didn't buy the headphones so I used a speaker I removed from an AM radio. I can't remember what happened to my Ocean Hopper but there are little bits and pieces of my memory that suggests I cannibalized it the following year! I don't believe that I would have torn it apart had it worked.....

I have been looking for another Ocean Hopper for about ten years. My Ocean Hopper want ads in Electric Radio attracted the attention of Mike Sewell, K0CRX. After exchanging several very

enjoyable letters, he sold me his Ocean Hopper. In addition to the Ocean Hopper was an original manual and a complete set of original coils.

Mike shipped me the Ocean Hopper and I immediately turned it on with the broadcast band coil installed. What a gas!! This was much more of a nostalgic experience than my recent AM QSO with my DX-40. It just brought back all kinds of really good memories. The Ocean Hopper worked very well on the broadcast band and OK on the 1.7 - 4.1 Mhz band. It had been "repaired" several times and the top of the chassis was somewhat corroded. The wiring left a whole lot to be desired with several very cold solder joints.

Cosmetically, this Ocean Hopper was in reasonably good condition. Since the manual is marked 83 Y 749, this Ocean Hopper was built after 1958. This Hopper appears to be a very late model, possibly among the last that were sold?? The tubes are original Knight and have mid-1960 date codes - 6448 (50C5), 6452 (35W4), and 6513 (12AT6). The Ocean Hopper was still listed in Allied's 1966 catalog for \$15.95.

I decided to completely strip the chassis, make mechanical drawings of the sheet metal, and rewire it using as many "period parts" as I could get.



The Ocean Hopper reduced to kit form. All the parts have been cleaned and tested and are ready for assembly.



I took a **very deep breath** and proceeded to strip the Hopper down to the bare chassis. I then spent a couple of hours cleaning up the parts that I intended to save. Actually, very little was "tossed". I "tossed" the orange drop caps, all the new style aluminum electrolytics, most of the 6-32 hardware, the 200 $\Omega$  10W resistor, and one tie strip. Everything else was OK!

I decided not to paint the chassis gray. I coated the rust spots with naval jelly and then wire brushed the chassis with a fine wire wheel. I then gave the chassis several coats of clear Krylon to protect it from rusting. The chassis looks very much original in this condition as opposed to the gray. I suspect that the wire brushing removed most of the original plating so I am hoping that the heavy Krylon coat will protect the steel from rust - if not, I can always paint it gray.

I mounted the parts, including the original wafer sockets, with new 6-32 hardware. I cleaned both sides of the front panel with Meguiar's Car Cleaner/Wax before mounting and that really cleaned it up. I had previously sent the front panel out and had a silkscreen master made of it in case I wanted to make a new panel.

I rewired the Hopper using the original wiring guide using the same color codes for the wires. I used 20 gauge insulated/stranded instead of the original 24 (?) gauge. I made a few subtle changes in the wiring just to make it easier to wire. I spent about \$7 for the additional parts, which includes the 3-section electrolytic from Antique Electronic Supply.

I used liberal amounts of FANTASTIK cleaner to remove the stains from the Hopper's cabinet followed by a coat of the TANNERY. The cabinet came out much better than I expected!

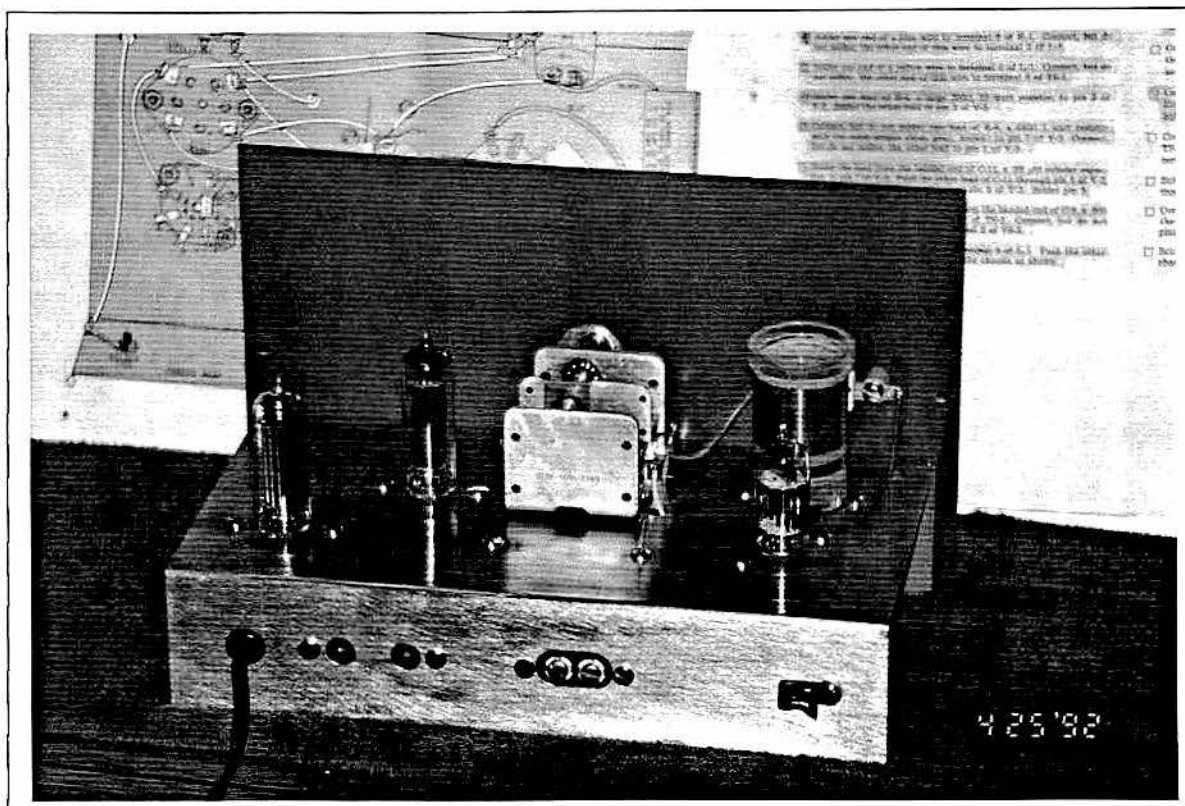
Unlike the first Ocean Hopper that I built in 1958, this one worked the first time - **it took me 34 years to get it right!!!** My rebuilt Ocean Hopper now sits on the shelf besides my 75A-4 and I get it down occasionally to relive some memories.

The Ocean Hopper coils are wound on standard 1-1/4" dia. x 2-1/4"H 5-pin rim-type coil forms. The following coil winding information was obtained using an Ocean Hopper coil set:

#	Freq Range	L	Np	Ns	TPI	AWG	Length
1	15.5-35MHz	0.1uH	2-3/4	2-3/4	2.9	20	0.95"
2	7.0-17.5MHz	2.9uH	8-3/4	3-3/4	10.9	20	0.80"
3	2.9-7.3MHz	18.0uH	24-3/4	3-3/4	28.4	20	0.87"
4	1.65-4.1MHz	51.0uH	42-3/4	7-3/4	47.0	24	0.91"
5	530-1900KHz	136uH	73-1/4	13-1/4	74.0	28	0.99"
6	165-540KHz	1.53mH	pi	34-3/4	-	-	-

Notes:

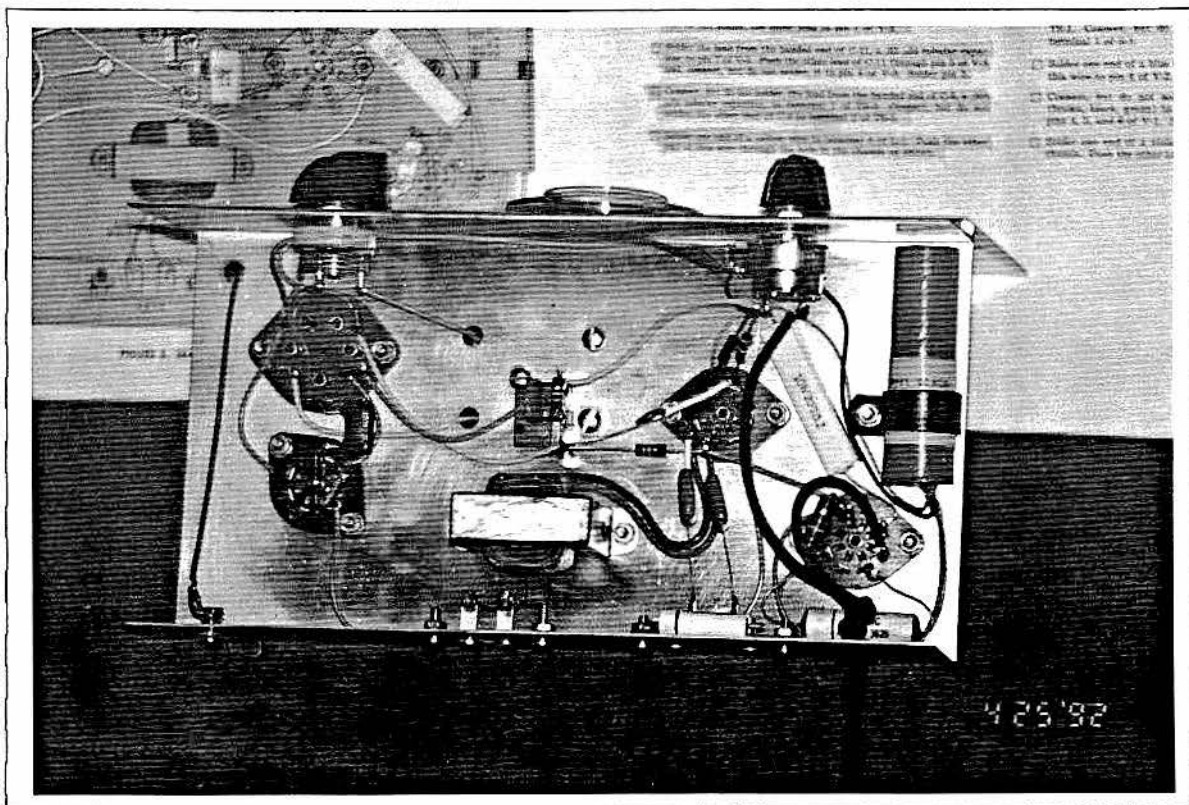
1. Inductances measured w/Sencore Model LC53 "Z Meter".
2. Jumper pins 4-5 on BC and Long-Wave coils only.
3. Bandset cap A=180uuF, B=440uuF.
4.  $N_p$  = primary turns.
5.  $N_s$  = secondary turns.
6. Length = length of the primary winding.
7. TPI = primary turns/inch =  $N_p/\text{Length}$



Rear view with the broadcast-band coil installed. Tubes are, right-to-left: 12AT6, 50C5, and 35W4. The front panel ANTENNA TUNING capacitor is insulated from the panel using 7/16" long ceramic spacers.

Many Ocean Hopper schematics call out the wrong pin numbers for L1. The pin numbers correspond to the assigned pin numbers on the wiring diagrams in the manual but are not compatible with a 5-pin socket. The coil drawings and schematic included with this article indicate the "correct" pin numbers.

A parts list and CAD drawings of the sheet metal have been included to aid the reader in repairing and/or restoring their Ocean Hopper. My thanks to Warren Ruland for converting my pencil layouts of the sheet metal to CAD. The P/N's listed in the right-hand column are Allied Radio P/N's.



Under chassis view. The electrolytic filter capacitor is from Antique Electronic Supply. A cable clamp is used to mount the electrolytic. The wafer-type tube sockets are original.

One word of caution using the Ocean Hopper. The Hopper is an AC/DC receiver - one side of the line is connected to the chassis through a 0.05uF/270K parallel network - the chassis can be "hot" if the plug is reversed. I don't take any chances and use a 115V-115V isolation transformer, a Triad N-53M. It might be useful to repeat the warning found in the Ocean Hopper's manual:

**"CAUTION: NEVER TOUCH ANY PART OF THE WIRING WHILE THIS RECEIVER IS PLUGGED INTO A POWER OUTLET. NEVER USE OR TEST THE OCEAN HOPPER ON OR NEAR A GROUNDED METAL BENCH, RADIATOR, SINK OR OTHER GROUNDED METAL OBJECT. SERIOUS BODILY INJURY OR PROPERTY DAMAGE MAY RESULT IF THIS WARNING IS NOT HEHEDED."**

This article was written 9/92 and originally appeared in Electric Radio, Oct.'92, issue #42, "Regeneration Fever", pgs. 20-25.

#### Selected References:

1. "An "Ocean Hopper" Reunion", Randy W. Barthel, KF8TV, QST, Jul.'93, pgs. 54-55.
2. "The Ocean Hopper Story", World of Ideas Column ("Homebrew Classics From The Fifties - Part I"), Dave Ingram, K4TWJ, CQ Magazine, Feb. '94, pgs. 94-98.
3. "A "New" Hopper", David W. Ishmael, WA6VVL, The Ocean Hopper Newsletter, K7JYE, June '92, Issue #4.

4. "A "NIB" Hopper", Bill Ross, KY9M, The Ocean Hopper Newsletter, K7JYE, Mar. '93, Issue #6.

Note: Bill Albrant, K7JYE, published six Ocean Hopper Newsletters from Sep.'91 to Mar.'93. Although no longer published or available, copies of these newsletters might be obtained using the WANTED ads in (say) Electric Radio.



The author with the restored Ocean Hopper. The Ocean Hopper was my first kit and first receiver built in 1958 when I was fourteen. It took me thirty-four years to get my second Hopper.

Note: Replica Ocean Hopper front panels with silkscreen matching that on pg. 14 are available for \$20 postpaid from DWI Engineering, P.O. Box 3611, Costa Mesa, CA, 92628-3611. The 6" x 10" panels are steel, have been machined-punched, and were professionally painted and screened at a local firm. The color match and finish is very close to my sample Ocean Hopper. I have restored a total of four Ocean Hoppers and have noticed that the Knight Kit gray has not been consistent from lot-to-lot - at least w/Ocean Hopper front panels - so you might see a variation in color and finish from your existing panel. I used a front panel from a mid '60s Ocean Hopper to make the silkscreen master. The silkscreen had again changed by Allied's '66 catalog, so it doesn't represent the final panel's silkscreen.



- - - ALLIED RADIO KNIGHT KIT OCEAN HOPPER PARTS LIST - - -

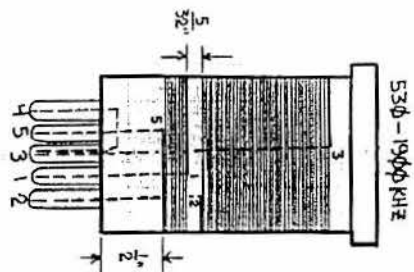
Ref	Description	Qty	P/N
C1	Capacitor, variable, 5-80 uufd, antenna tuning	1	283000
C2	Capacitor, variable, 15 uufd, bandsread	1	281000
C3	Capacitor, variable, dual-section, bandset Front section = 180 uufd Rear section = 440 uufd	1	282004
C4,7	Capacitor, paper, .05 ufd 400 WVDC 7/16" dia. x 1-9/16" length	2	245055
C5	Capacitor, mica, 100 uufd 20%	1	266017
C6	Capacitor, mica, 250 uufd 600 WVDC	1	266258
C8,10	Capacitor, paper, .1 ufd 200 WVDC 1/2" dia. x 1-9/16" length	2	243014
C9	Capacitor, paper, .005 ufd 600 WVDC 5/16" dia. x 1" length	1	247056
C11	Capacitor, paper, .02 ufd 400 WVDC 3/8" dia. x 1-1/8" length	1	245025
C12	Capacitor, electrolytic, 3-section 30-30-20 ufd 150-150-25 WVDC	1	213301
L1	Coil, standard, 530-1900 KHz	1	111204
L1	Coil, optional, 165-540 KHz	-	83Y741
L1	Coil, optional, 1.65-4.1 MHz	-	83Y742
L1	Coil, optional, 2.9-7.3 MHz	-	83Y743
L1	Coil, optional, 7.0-17.5 MHz	-	83Y745
L1	Coil, optional, 15.5-35.0 MHz	-	83Y744
L2	Choke, 5.5 Hy 2" mtg. ctrs. coil res. = 300 ohm	1	140003
R1	Resistor, variable, 10K regeneration control	1	390002
R2	Resistor, carbon comp, 1M 1/2W	1	301105
R3	Resistor, carbon comp, 270K 1/2W	1	301274
R4	Resistor, wirewound, 200 10W RCD PW10	1	374001
R5	Resistor, carbon comp, 82K 1/2W	1	301823
R6	Resistor, carbon comp, 470K 1/2W	1	300474
R7	Resistor, carbon comp, 150 1/2W	1	301151
R8	Resistor, carbon comp, 680 1W	1	304681
S1	Switch, SPST (part of R1) Clarostat SPST 3A 125V		
T1	Transformer, audio output 2.5K single-plate to 3.2 ohm voice coil 2" mtg. ctrs., 1-3/8" height pri. res. = 180 ohm, sec. res. = 0.5 ohm similar to TRIAD S-2X, S-1X, S-30X	1	102200
V1	Tube, 12AT6 - regenerative detector	1	611014
V2	Tube, 50C5 - audio amplifier	1	610026
V3	Tube, 35W4 - rectifier	1	610029

ANT	Clip, brass, fahnestock 5/16" wide x 25/32" high, #6 mtg. hole Waldom C-102 H.H. Smith 533	1	533003
TS1	Terminal Strip, solder type, 3-terminal Waldom TS-4 H.H. Smith 864 (standard size) TRW 52A	1	440301
TS2	Terminal Strip, screw type 2-terminal (spkr) 1-5/16" mtg. ctrs. Waldom BTS-19 TRW 17-2 Keystone 4188	1	441201
TS3	Terminal Strip, phone-tip, 2-terminal 1-5/8" mtg. ctrs.	1	502227
V1-3	Socket, wafer, 7-pin miniature large pattern - 1-5/16" mtg. ctrs.	3	501070
L1	Socket, wafer, 5-pin 1-1/2" mtg. ctrs.	1	501050
C1	Spacer, ceramic 6-32 threads, 3/8" dia. x 7/16" length	2	940004
	Screw, 6-32 x 5/16"	19	560343
C1	Screw, 6-32 x 1/4"	4	560342
	Screw, self-tapping, #4 x 1/4"	2	562292
	Nut, hex, 6-32 x 1/4"	16	570340
R1	Nut, hex, 3/8"	1	570840
R1	Washer, lock, 3/8"	1	582700
ANT	Washer, fiber, shoulder, #6	1	591300
ANT	Washer, fiber, flat, #6	1	590301
C1,ANT	Lug, solder, #8	3	553002
	Grommet, 3/8"	2	830200
	Cord, line, 2-conductor similar to Radio Shack 278-1255	1	802001
C3	Knob, bandset	1	764503
C3	Scale, dial	1	870009
C2,R1	Knob, bar 1-1/4" dia. x 5/8" height Waldom WA-2300 H.H. Smith 2220	2	762201
	Cabinet, wood, vinyl covered	1	702006
	Chassis	1	461314
	Panel, front	1	462211

Notes:

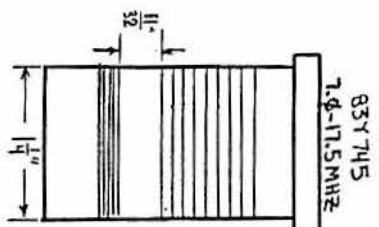
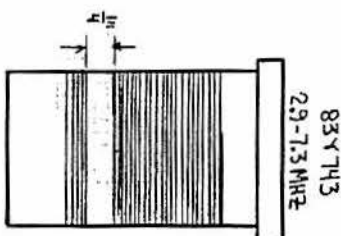
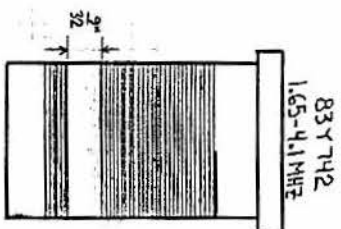
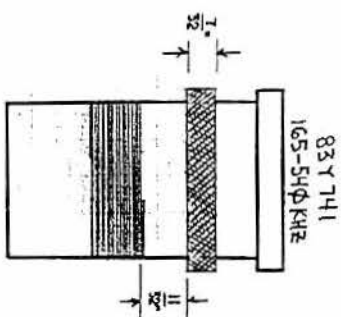
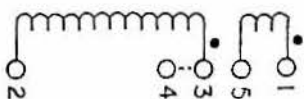
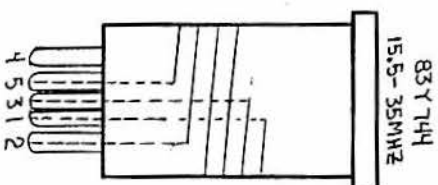
1. The wood cabinet is made by American Trunk & Case, Inc., Chicago. This has been shortened to ATC on one cabinet.
2. The ceramic capacitors are made by American Radionic Co., Inc., and have the trade name CERACAP. The dimensions of the caps listed in the parts list were obtained from these capacitors.
3. P/Ns in the right-hand column are original Knight and in some cases are printed on the body of the component.
4. ATC is also stamped on T1 and L2 (?).





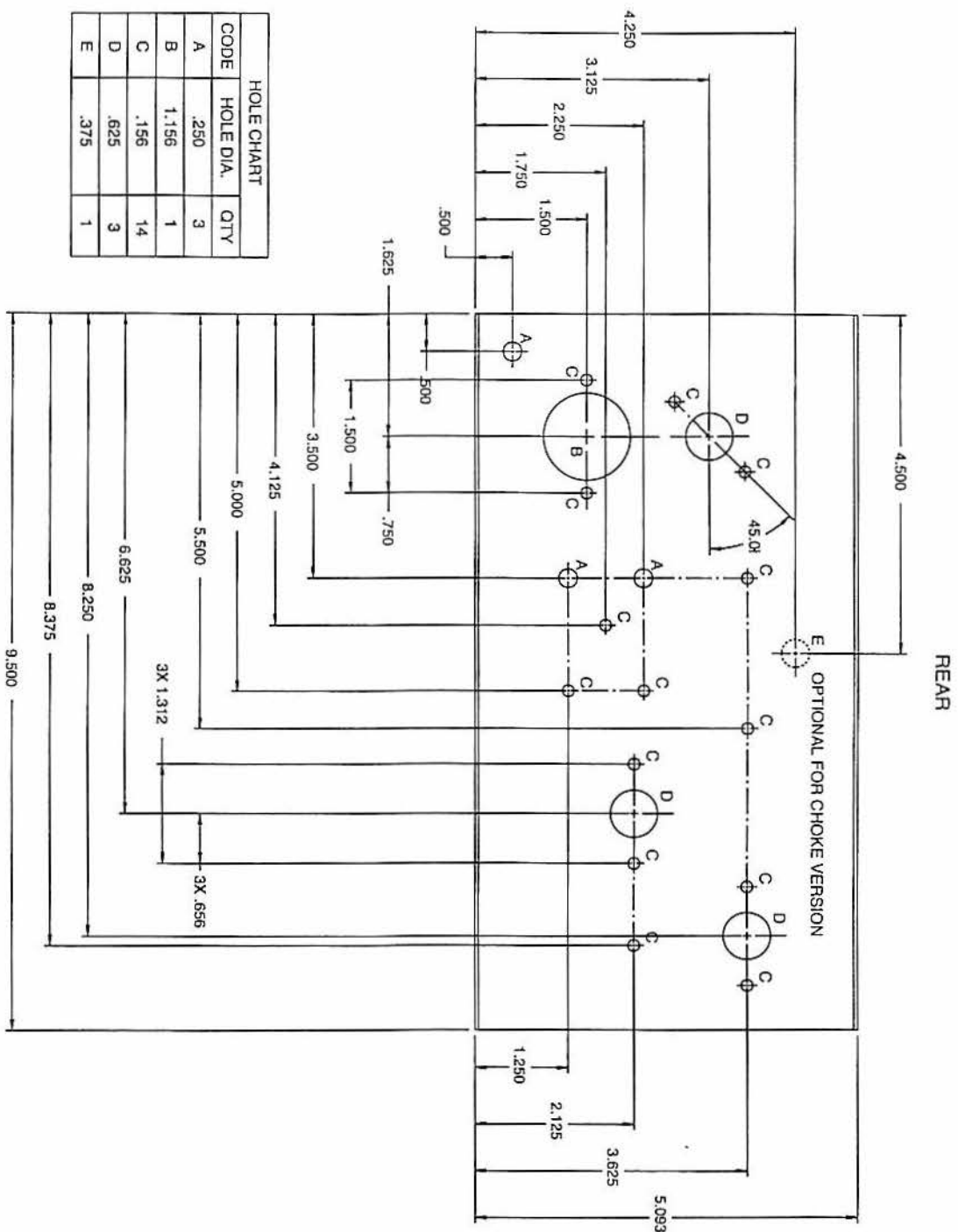
#	Freq Range	L	Np	Ns	TPI	AWG	Length (p)
1	15.5-35MHz	0.1uH	2-3/4	2-3/4	2.9	20	0.95"
2	7.0-17.5MHz	2.9uH	8-3/4	3-3/4	10.9	20	0.80"
3	2.9-7.3MHz	18.0uH	24-3/4	3-3/4	28.4	20	0.87"
4	1.65-4.1MHz	51.0uH	42-3/4	7-3/4	47.0	24	0.91"
5	530-1900KHz	136uH	73-1/4	13-1/4	74.0	28	0.99"
6	165-540KHz	1.53mH	pl	34-3/4	-	-	-

Notes:  
 1. Inductances measured w/Sencore Model IC53 "Z Meter".  
 2. Jumper pins 4-5 on BC and Long-Wave coils only.  
 3. Bandset cap A=180uuf, B=440uuf.



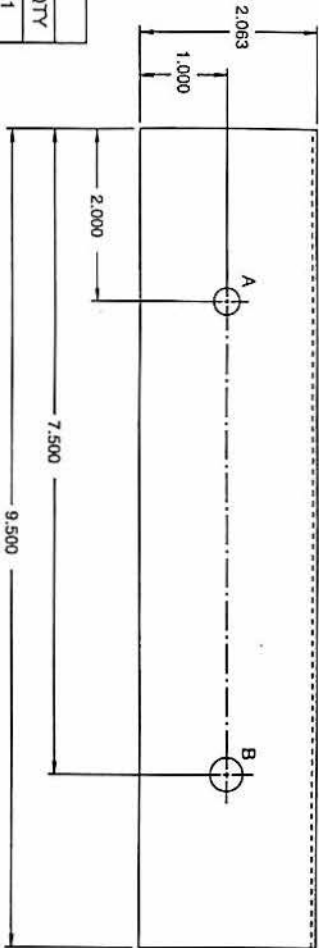
# OCEAN HOPPER (749) COIL SET DWISH W66VL 17MAY92 REV D





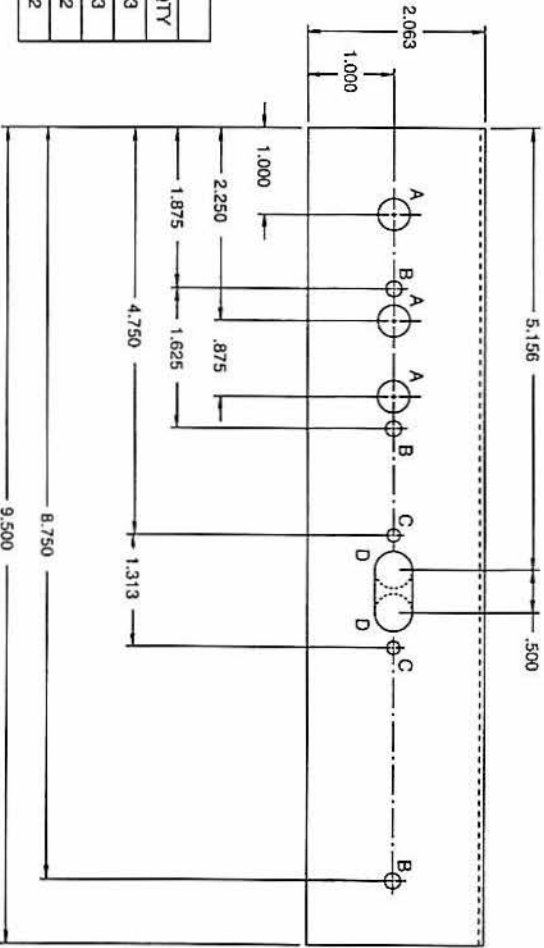
- NOTES:
1. OVERALL OUTSIDE DIMENSIONS OF THE STEEL CHASSIS IS 2.063 HIGH X 5.093 DEEP X 9.500 WIDE.
  2. ALL DIMENSIONS TAKEN FROM "OCEAN HOPPER CHASSIS."

HOLE CHART		
CODE	HOLE DIA.	QTY
A	.312	1
B	.390	1

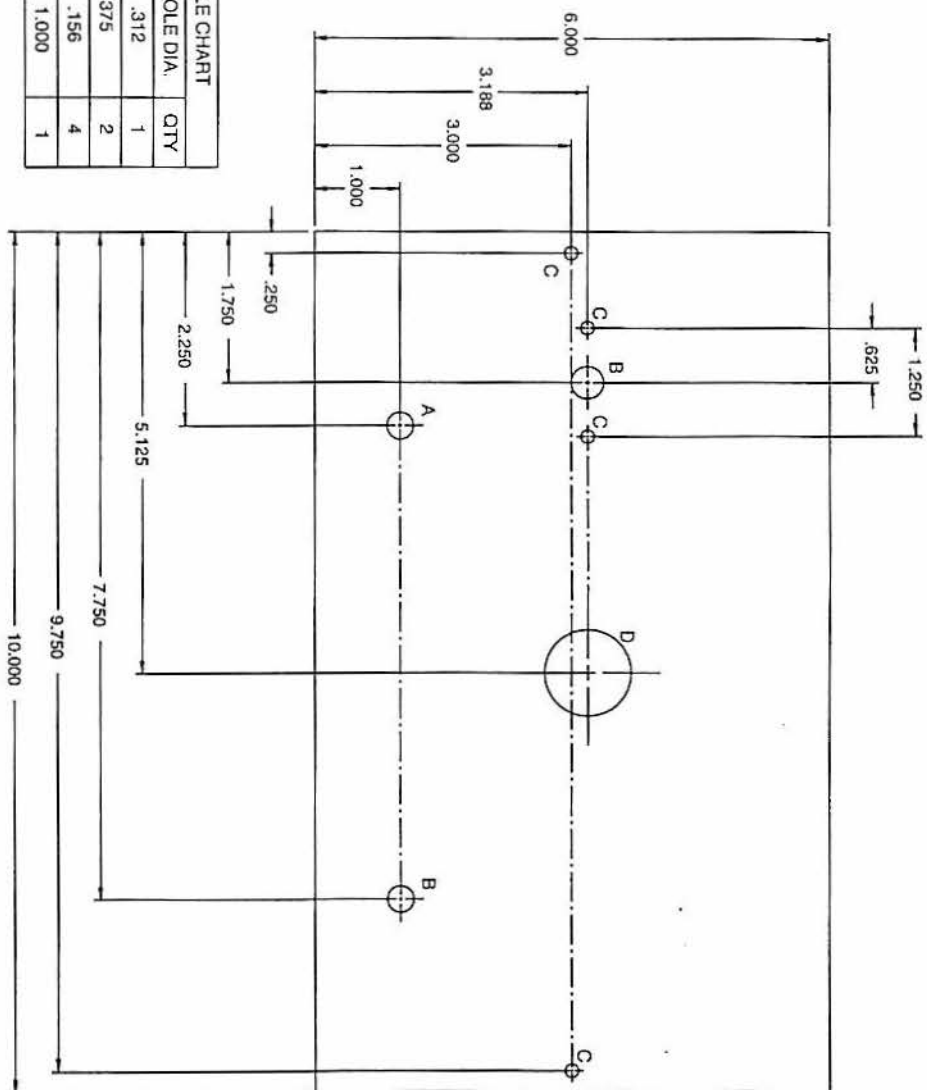


FRONT VIEW OF CHASSIS

HOLE CHART		
CODE	HOLE DIA.	QTY
A	.375	3
B	.188	3
C	.156	2
D	.438	2



### REAR VIEW OF CHASSIS



FRONT PANEL

# 1. OCEAN HOPPER FRONT PANEL

MATERIAL: 6.000 x 10.000 x .0396 THICK WITH PAINT ON BOTH SIDES.

NOTES:

ANTENNA TUNING

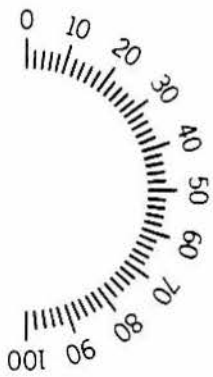
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***knight***  
OCEAN HOPPER

BAND SPREAD



REGENERATION



ALLIED RADIO - CHICAGO

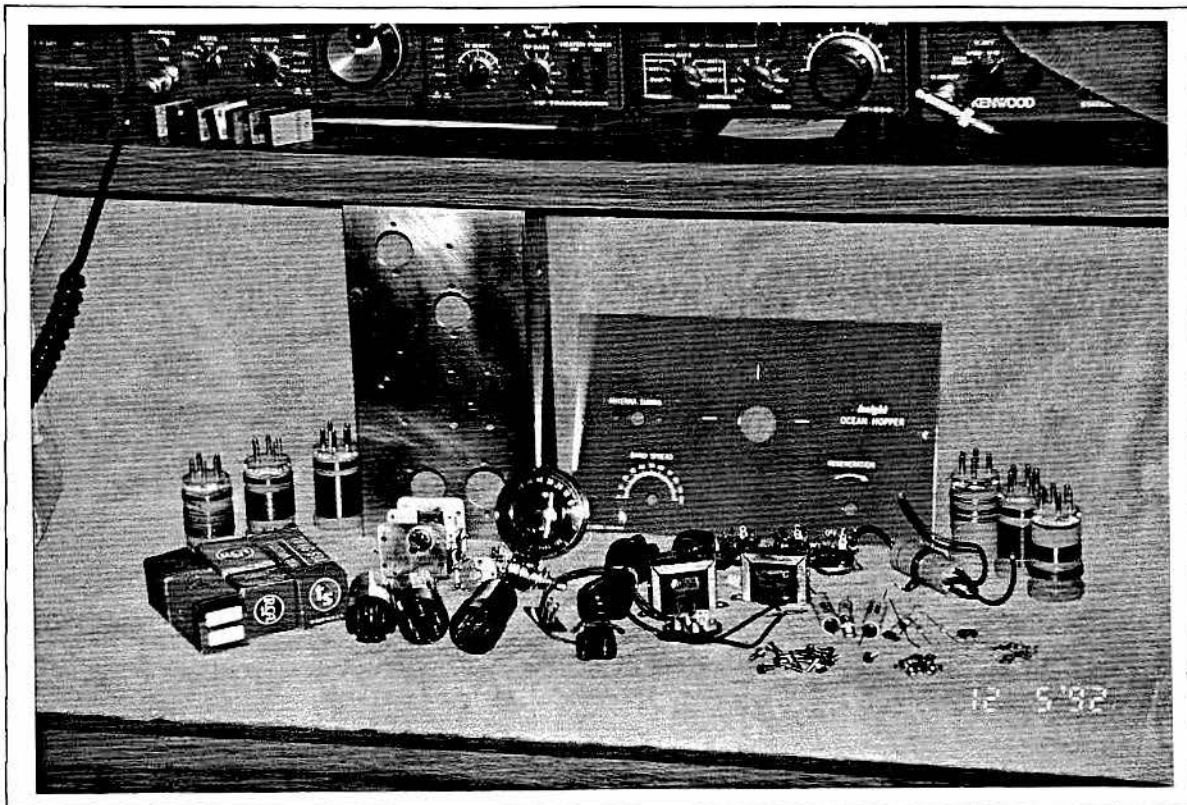
OFF / \

MADE IN U.S.A.

- - - OCEAN HOPPER MKII - - -  
"VINTAGE CONVERSION"

Ever since I finished my first Ocean Hopper restoration (ER#42), I have been thinking about building a 2nd Ocean Hopper and changing the 7-pin miniature 12AT6, 50C5, and 35W4 tubes to their octal equivalent 12SQ7, 50L6, and 35Z5. Given the long "octal history" of the various Knight Ocean Hoppers, I felt it was only appropriate to end the Ocean Hopper line with an octal version. Besides, the chassis looks more "balanced" using octal tubes!

Bill/WB8YUW answered my ad in Electric Radio and told me that a friend had an Ocean Hopper for sale. I called the number Bill gave me and bought my second Ocean Hopper this year. When it arrived, I knew that this Hopper was the perfect candidate for my "vintage conversion". The front panel had two extra holes in it and the chassis had an extra hole. I didn't feel too guilty about modifying a modified Hopper.



The octal-conversion Ocean Hopper reduced to kit form.

I stripped the chassis down to the bare chassis and spent a couple of of hours cleaning up the original parts. I then punched out the 7-pin holes to 1" using a chassis punch. The 7-pin wafer sockets used in the Hopper use 1-5/16" mounting centers. Small-pattern octal sockets can be found that use a 1" diameter hole with 1-5/16" mounting centers. This mod is pretty straight

forward and the original 7-pin wafers can be used if you decide to restore the Hopper to its original 7-pin tubes, although the hole will now be 1" instead of 0.624".

This chassis was badly corroded so I used my hand drill and wire wheel to clean up the outside of the chassis. This was followed by two coats of gray primer. The chassis was now ready for assembly.

With the exception of the different pin numbers and octal sockets, the schematic/assembly of the "vintage conversion" Ocean Hopper is very close to the original. I made an assembly diagram for the octal version and this made assembly a snap. I assembled the Hopper while I was listening to the 40M swap net and it went very quickly. I was able to use all of the original tubular caps which makes this version a bit more authentic than the 1st. I checked all caps for value and leakage before they were installed. The Sprague TVA 3448 electrolytic is not original but it is perfectly acceptable for this rebuild. The TVA's leakage was checked to 150VDC and it was surprisingly very low - it was in better shape than some of the new electrolytic caps that I have purchased at the local electronics store!

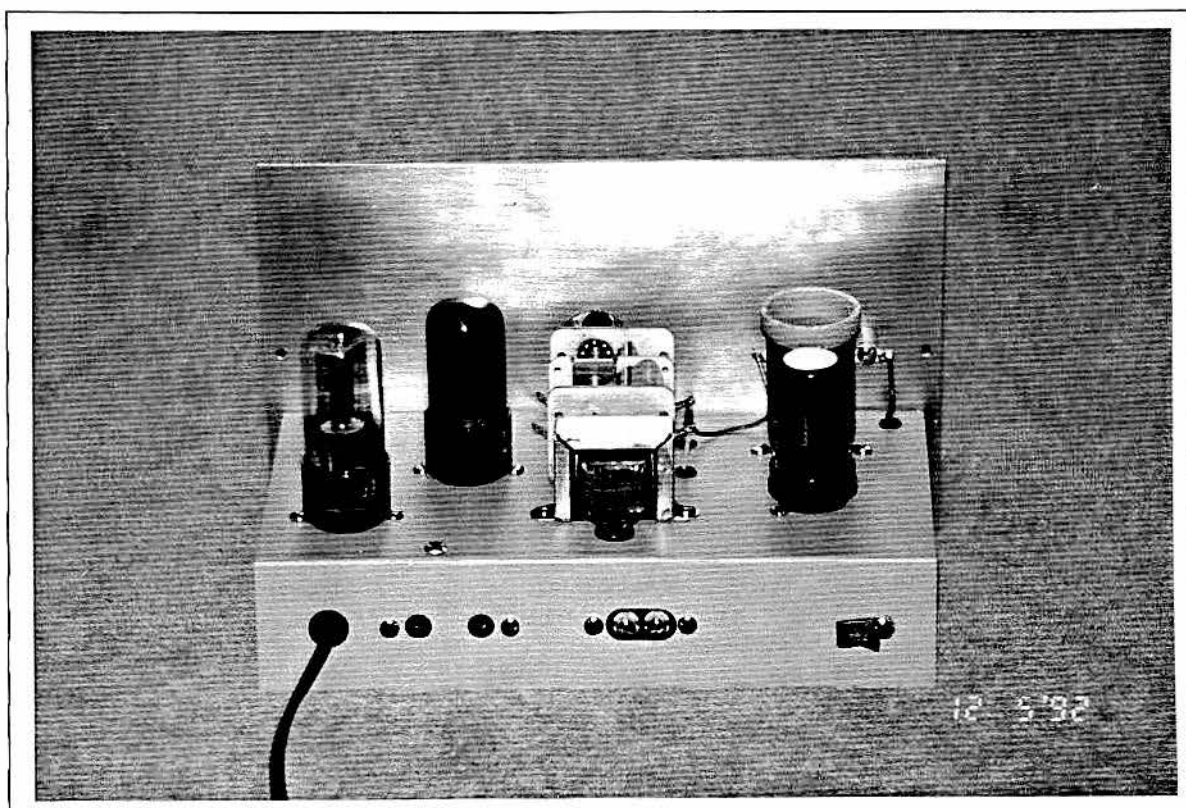


The front panel is homebrew, fabricated from 0.062" aluminum. The panel was painted pseudo Knight gray and silkscreened using a Jennings model T-404-2 T-shirt printer. The silk-screen master (pos) was made from an original Ocean Hopper front panel.



The finished wiring is surprisingly close to the original Hopper. So close that one might be fooled into believing that this is a legitimate version of an Ocean Hopper. Even though this version is NOT legitimate, I prefer it to the original.

The front panel had been made from 0.062" aluminum using the plans I made from the 1st Hopper in Aug '92 in anticipation of finding another Ocean Hopper "suitable" for this conversion. It was painted a gray that is close enough to the Knight gray and silkscreened using a Jennings model T-404-2 T-shirt printer. The silkscreen artwork master/positive was made using the 1st Hopper's panel. At first blush, you will not be able to tell it's a copy.....

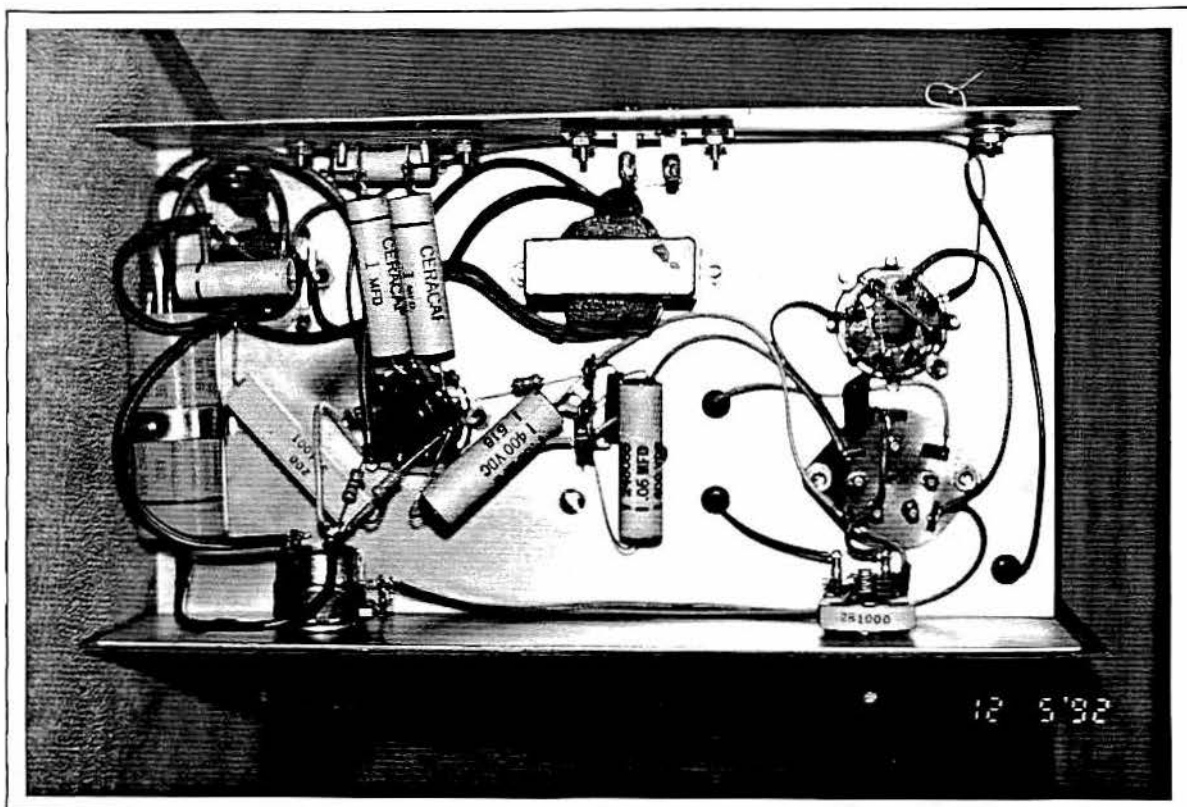


Rear view with the broadcast-band coil installed. The tubes are, right-to-left, 12SR7, 35L6, and 45Z5. In spite of being a "forgery", this is my favorite Hopper.

I checked out the wiring and installed the only tubes I had on hand - 12SR7, 35L6, and 45Z5. The 12SQ7, 50L6, 35Z5 were on order from Antique Electronic Supply and didn't get here quick enough! I did a side-by-side comparison between the two Hoppers - the two seem to be pretty similar on the broadcast band in terms of sensitivity/stations heard.

This was a fun project to do over a rainy overcast weekend. Start to finish took the better part of a day. I'm not sure I would make this conversion to a perfectly operating, cosmetically

nice Hopper, but it might be tempting if you run into a Hopper that needs a lot of TLC or is no longer original. My total investment in this project is (only) \$32 plus \$15 for a 2nd set of tubes from AES (the spares can also be used for an S-38A-D or your "favorite" 5-tube AC-DC radio).



Under chassis view. The tubular caps are original. The wiring of the octal version, at first blush, looks original.

This article was written 12/92.

Selected References:

1. "Vintage Conversion", David W. Ishmael, WA6VVL, Ocean Hopper Newsletter, K7JYE, Mar.'93, issue #6.



- - - 30-30 2-TUBE REGENERATIVE RECEIVER - - -  
A.K.A THE DOERLE "GLOBE CIRCLER"

In 1956 when I was in 6th grade and just discovering "radio", I spent a lot of time dreaming about the one and two-tube breadboard radios described in a school library book. I even spent a few unsuccessful Saturdays walking around Newport Beach, CA, trying to find some of the parts. Unlike Bob Dennison/W2HBE (The Schoolboy's 1934 All-Electric Radio, ER#5), I never built that receiver.

It wasn't until two years later that I built my first receiver, a Knight kit Ocean Hopper. Even then, I don't remember it ever working. After 34 years, I recently acquired my second Ocean Hopper and completely rebuilt it - a very satisfying and nostalgic experience.

Still, I have always wanted to build that one or two-tube breadboard radio. It wasn't until I discovered ER last year and Bob's article that I started collecting the parts and articles on one- and two-tube regenerative receivers.

The receiver I chose to build is a classic 2-tube regenerative receiver described by Walter C. Doerle in the "1934 Official Short Wave Radio Manual" (originally published in the December 1931 Short Wave Craft). The Doerle "Globe Circler" is similar to hundreds of designs printed in hundreds of books and magazines. Dave Ingram/K4TWJ describes a model 30-30 Doerle receiver in his recently published "Keys, Keys, Keys". I used his model 30-30 for my receiver as the type 30 tube is very common for these receivers and is used in mine.

I will be the first to admit that I committed a bit of heresy by using 6" x 9" plexiglass for the base and front-panel. I had eliminated an aluminum chassis/front-panel right from the start. My wood working skills leave a whole lot to be desired and I had been thinking about using plexiglass for some time. I underestimated how flexible the 1/8" front-panel would be and had to stiffen it up using brass stock. I eventually added a U-bracket to the rear of C5, the regeneration control, to get the desired front-panel stiffness.

In spite of the plexiglass, I tried to use as many parts as possible from the original 1934 design(s):

- \* The two 30 tubes are Silvertone 230s dated 12/7/33.
- \* The 6 plug-in coil set was manufactured by Alden Mfg. Co. and is thoroughly covered in the "1934 Official Short Wave Radio Manual".
- \* The 4-pin tube sockets are Benjamin and were obtained from Antique Electronic Supply. These were patented in 1911 and 1925 and were used extensively in 1930s designs.
- \* The interstage transformer, coil-set, National Velvet Vernier dial, antenna trim cap, knobs, and tubes were resurrected

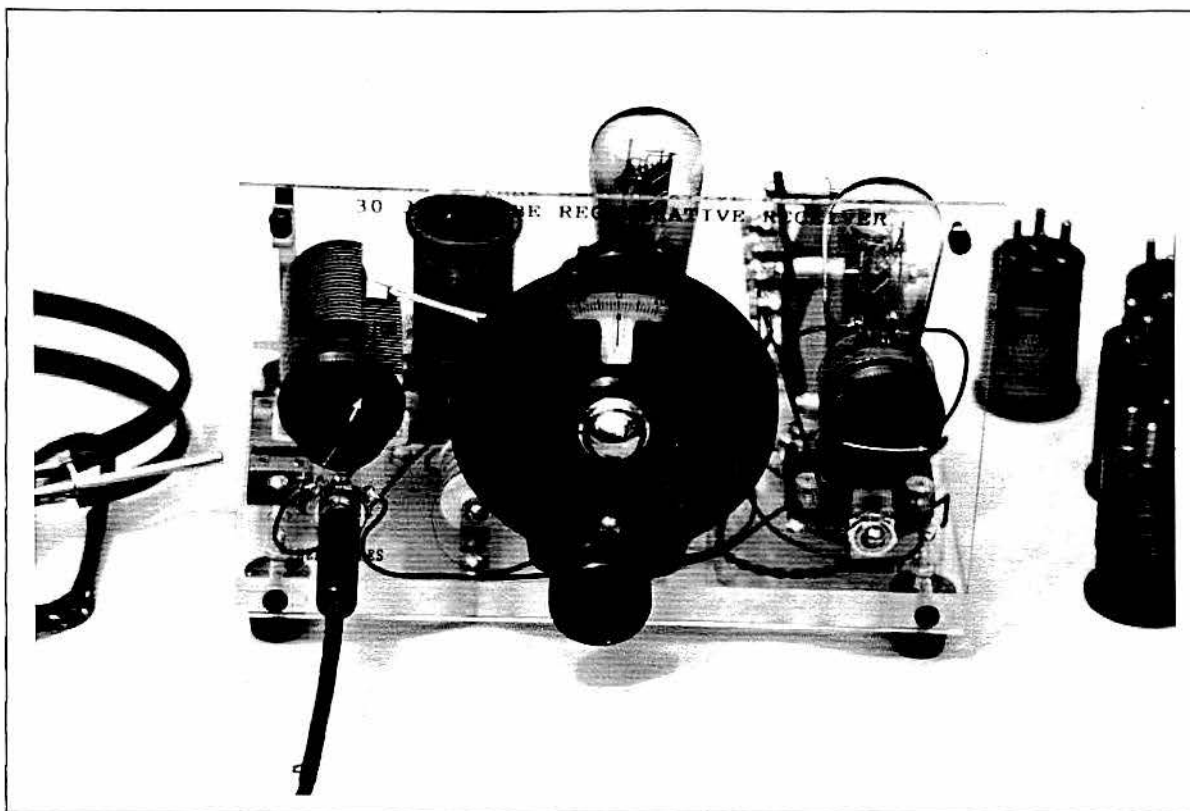
from a Doerle "Globe Circler" that was built as a kit in 1933 that I found at the local TRW swapmeet.

The interstage transformer was cleaned and repainted. New 6-32 hardware was used and the four terminals (P, B+, G, & A-) were made using 6-32 brass hardware.

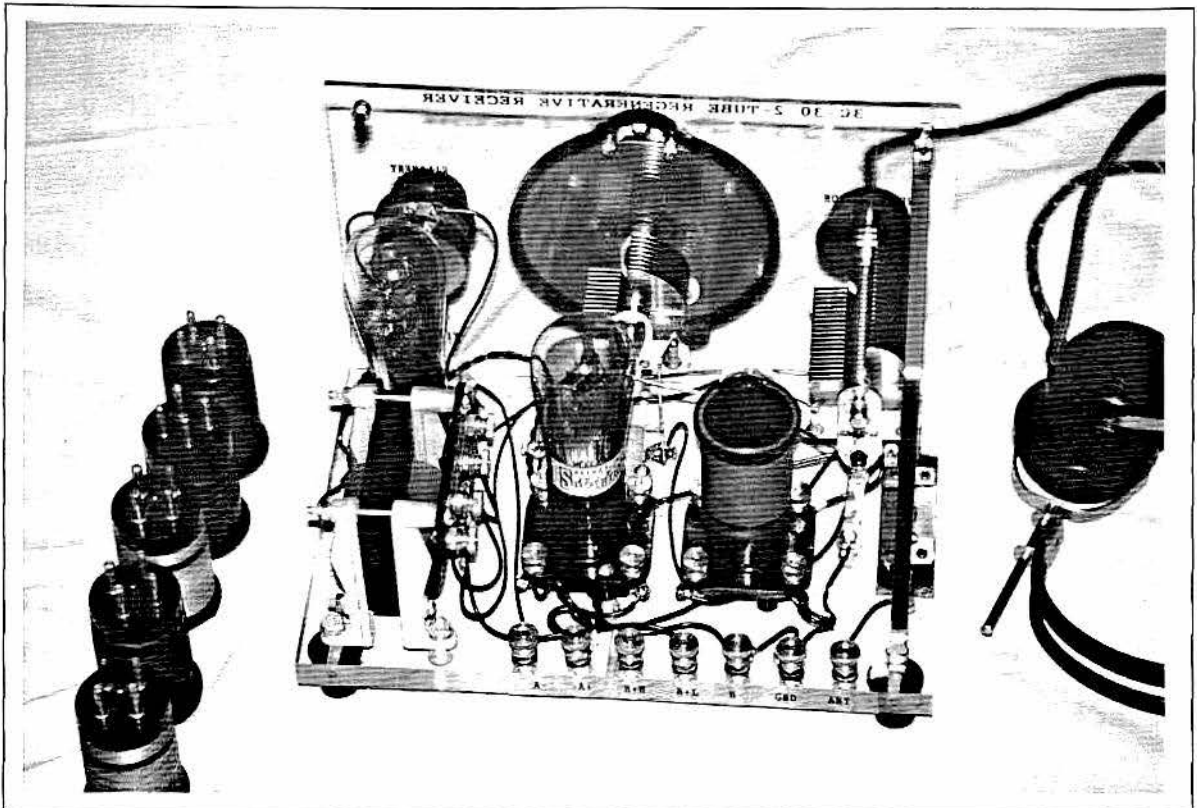
The seven terminals for the battery and antenna connections located on the base were made using 8-32 brass hardware.

The receiver was relatively easy to build. Finding the "right" parts was, by far, the toughest task. It took me four months to find the Hammarlund 8 mH Isolantite R.F. Choke once I started looking for it!!! These parts will NOT be on the swapmeet tables - they will be in the junk boxes under the tables! Had I not blundered into that Doerle at the TRW swapmeet, I would still be looking for many of the parts.

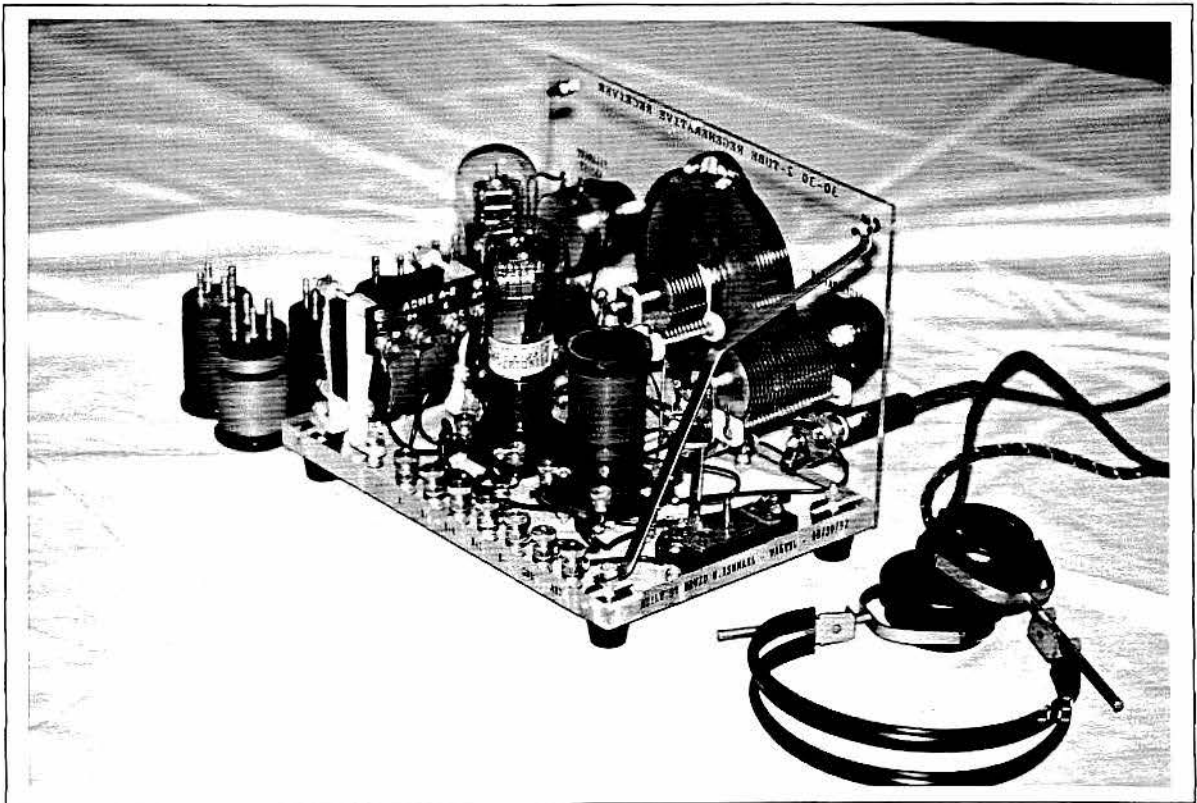
The front-panel was silkscreened using my son's Jennings model T-404-2 T-shirt printer using a 160 mesh screen. My son and I have been experimenting with silkscreening front panels and this is the first panel we have done for an actual project.



Front view of the 30-30 regenerative receiver. Controls, right-to-left, are: filament voltage adjust, main tuning, & regeneration.



Rear views of the 30-30, with Alden plug-in coils and headphones. Note the front panel stiffener and U-bracket at the rear of the regeneration control.



How does it work? Not being a regen guru, the only thing I can compare it to is my Knight Ocean Hopper. The 30-30 does work better than the Ocean Hopper. The National Velvet vernier dial is a **huge** improvement over the Ocean Hopper's direct tuning!! The proof-of-the-pudding was using it to make some CW QSOs.

My first QSO with the 30-30 rcvr and 6AG7/6L6 xmtr (ER#43) was on 40M with Bill Brannick/KC6SZE. This was my first QSO using a completely homebrew station. The xmtr worked fine but the 30-30 turned out to be marginal on 40M. Even with the 20:1 National vernier, the tuning rate is just too "fast". The 40M novice band is only 0.8 divisions wide on the dial which corresponds to (just)  $1.4^\circ$  of rotation of the tuning cap. Compare this to the 3.1 divisions/ $5.6^\circ$  of rotation for the 80M novice band using the same coil (yellow). Even the maligned BC-455 surplus command receiver covered the 40M novice band with  $4.6^\circ$  of rotation!.

Needless to say, most of my activity with the 30-30 was on 80M. I "temporarily sacrificed" 40M capability with the yellow coil by adding a 10 uufd fixed capacitor at C2. This gave me complete 80M coverage. The 80M coverage now occupies 31 divisions - more than adequate.

The 140 uufd tuning cap used in the 30-30 is a pretty common value for these types of receivers. When used with the Alden plug-in coils, the frequency coverage is as follows:

Coil	Inductance	Frequency Coverage
Orange	412 uH	0.60 - 1.19 MHz
White	115 uH	1.15 - 2.30 MHz
Green	60.9 uH	1.56 - 3.16 MHz
Yellow	11.8 uH	3.60 - 7.22 MHz

The 140 uufd tuning cap should be used for a "general coverage" (SWL) receiver. However, it is too large a value for amateur only coverage with the commercial Alden coils that I chose to use. After my (limited) experience with the 30-30, my next regen receiver will use a combination bandset/bandspread tuning scheme, much like the Ocean Hopper but with vernier tuning on the bandspread cap. For example, the Alden yellow coil requires a tuning capacitance of 175 - 134 uufd to cover the 3.5 - 4.0 MHz 80M band. The bandset capacitor is set to (say) 130 uufd and a 50 uufd bandspread capacitor is used to tune the band. The bandset capacitor doesn't have to be panel mounted for amateur only operation - it can be chassis mounted - adjusted once and forgotten.

The Alden coil set is thoroughly covered in the "1934 Short Wave Radio Manual". From my experience with the Alden coil set, you may want to wind your own coils to optimize the desired frequency coverage. If you do, you may want to consider the following:



\* Start out using the same form factor as a commercial coil. The tickler/feedback winding spacing can be critical. Don't overlook the polarity of the tickler winding.

\* The inductance of the coil can be calculated with a high degree of accuracy using the "tried and true" inductance formula in the ARRL handbook. Keep in mind that the calculation accuracy is only as good as your measurements.

\* C2 represents the circuits stray capacitance and fixed capacitance. I underestimated the value of stray cap when I did my original calculations. The 30-30's stray cap is approximately 30 uufd. Added to C3's 12 uufd minimum capacitance, this value of 42 uufd will limit the maximum tuning range for a given coil's inductance.

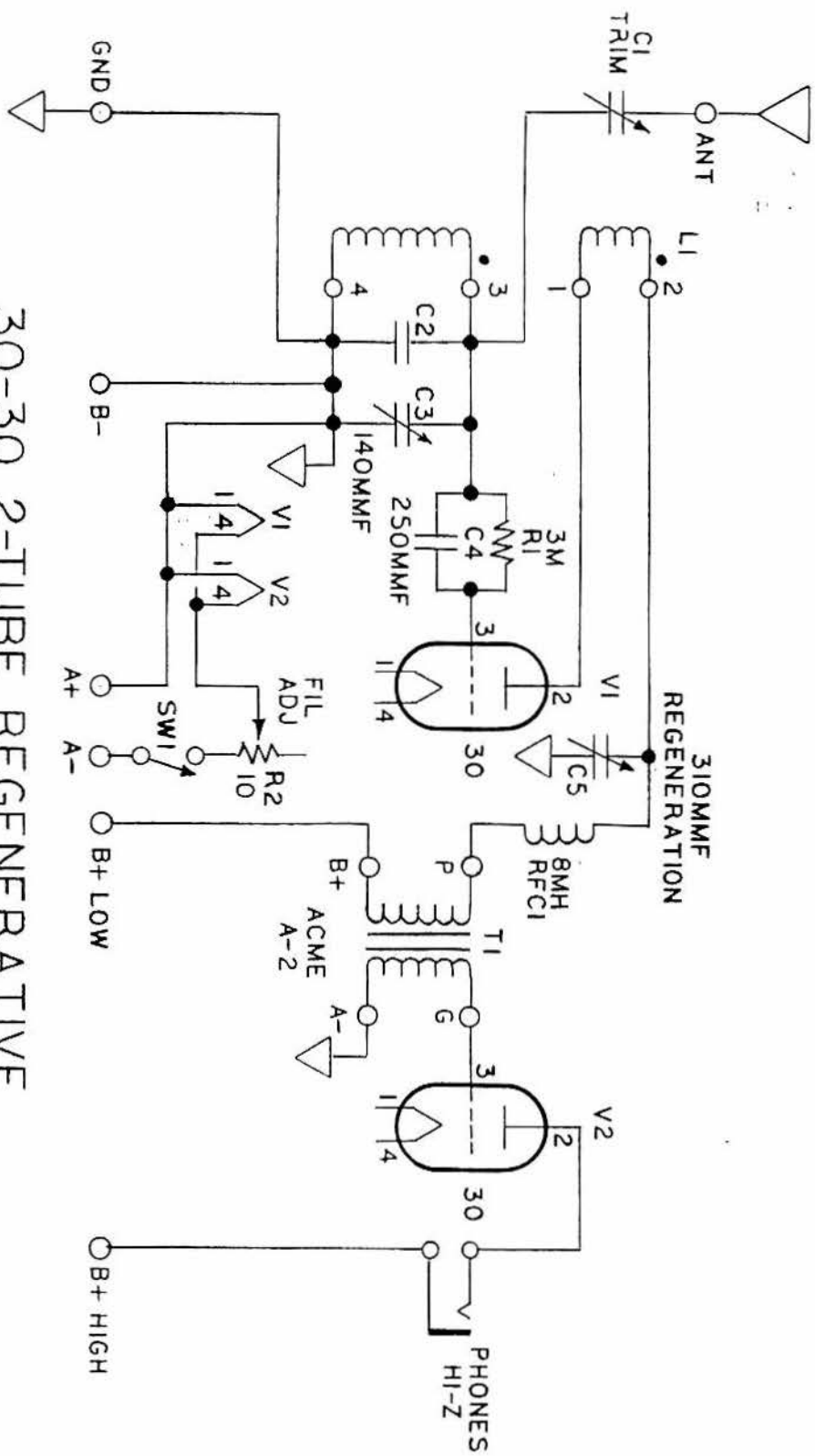
Was it worth the wait? You bet! I finally built the radio that got me into this hobby - 36 years later! For those of you that are interested in building these one or two-tubers from the 1930s, the reprints from Antique Electronic Supply are a treasure chest of information.

This article was written 9/92 and originally appeared in Electric Radio, Oct.'92, issue #42, "Regeneration Fever", pgs. 20-24, and Nov.'92, issue #43, "6AG7/6L6 25W CW Transmitter, 30-30 Postscripts", pgs. 20-22.

#### Selected References:

1. "The Schoolboy's 1934 All-Electric Radio", Bob Dennison, W2HBE, Electric Radio, Sep.'89, issue #5, pgs. 12-15, 27.
2. "Dad's Favorite Circuit - How to Build it...", Fixing Up Nice Old Radios, Ed Romney, N4DFX, 1990, pgs. 83-84.
3. "A Modern 2-Tube DX Receiver To Meet 1931's Strict Operating Standards", William I. Orr, W6SAI, CQ Magazine, June '72, pgs. 14-18.
4. "A Mating 30-30 Receiver", Keys-Keys-Keys, Dave Ingram, K4TWJ, CQ Communications, Inc., 1991, pgs. 88-89.
5. "1934 Official Short Wave Radio Manual", originally published by Short Wave Craft, 1934, and reprinted by Lindsay Publications, Inc., 1987. \*
6. "1934 How to Build and Operate Short Wave Receivers - Articles from Short Wave Craft Magazine", originally published by Short Wave Craft, and reprinted by Lindsay Publications, Inc., 1989. \*
7. "The Hammarlund 1937 Short Wave Manual", Third Edition, 1937, originally published by The Hammarlund Manufacturing Co., 1935, and reprinted by Lindsay Publications, Inc. \*
8. "Short Wave Beginner's Book", originally published by Radio & Television, 1940, and reprinted by Lindsay Publications, Inc. \*
9. "Short Wave Coil Data Book", originally published by Radio Publications, 1937, and reprinted by Lindsay Publications, Inc. \*

\* These books are available from Antique Electronic Supply, Tempe, AZ.

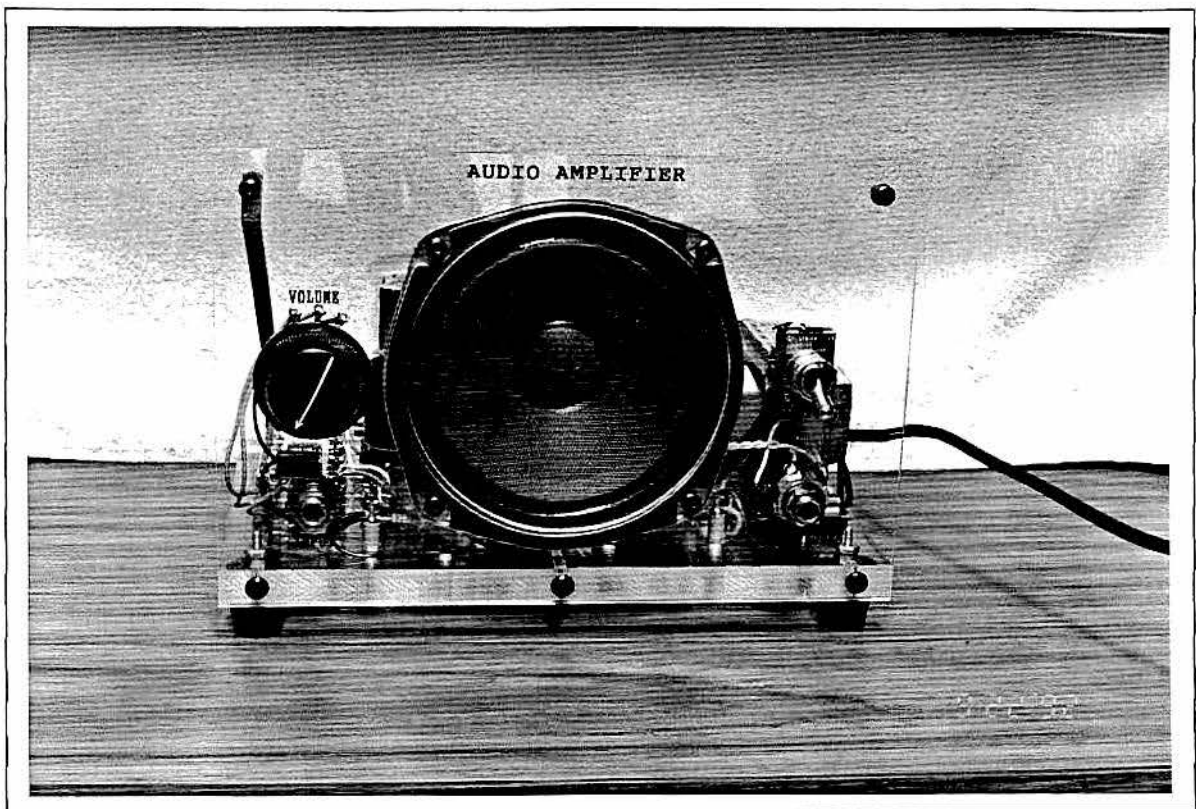


30-30 2-TUBE REGENERATIVE  
RECEIVER  
A.K.A. DOERLE "GLOBE CIRCLER"  
BY WA6VVL 8-30-92

- - - 30-30 AUDIO AMPLIFIER - - -

After using the hi-Z headphones with the 30-30 for a "couple of minutes", I connected my Heath Model T-4 Visual-Aural Signal Tracer to the 30-30's headphone jack and substituted a 47K plate load resistor for the 2K phones. Holy Cow - what a difference! The 30-30 was acting like a "real" radio. What a difference an audio amplifier makes.

Because of the success of using the Heath T-4, I designed and built a matching 6SN7/6V6/6X5 audio amplifier for the 30-30 and it really does make a big difference. The audio amp is also built on plexiglass and the front-panel was silkscreened like the 30-30.



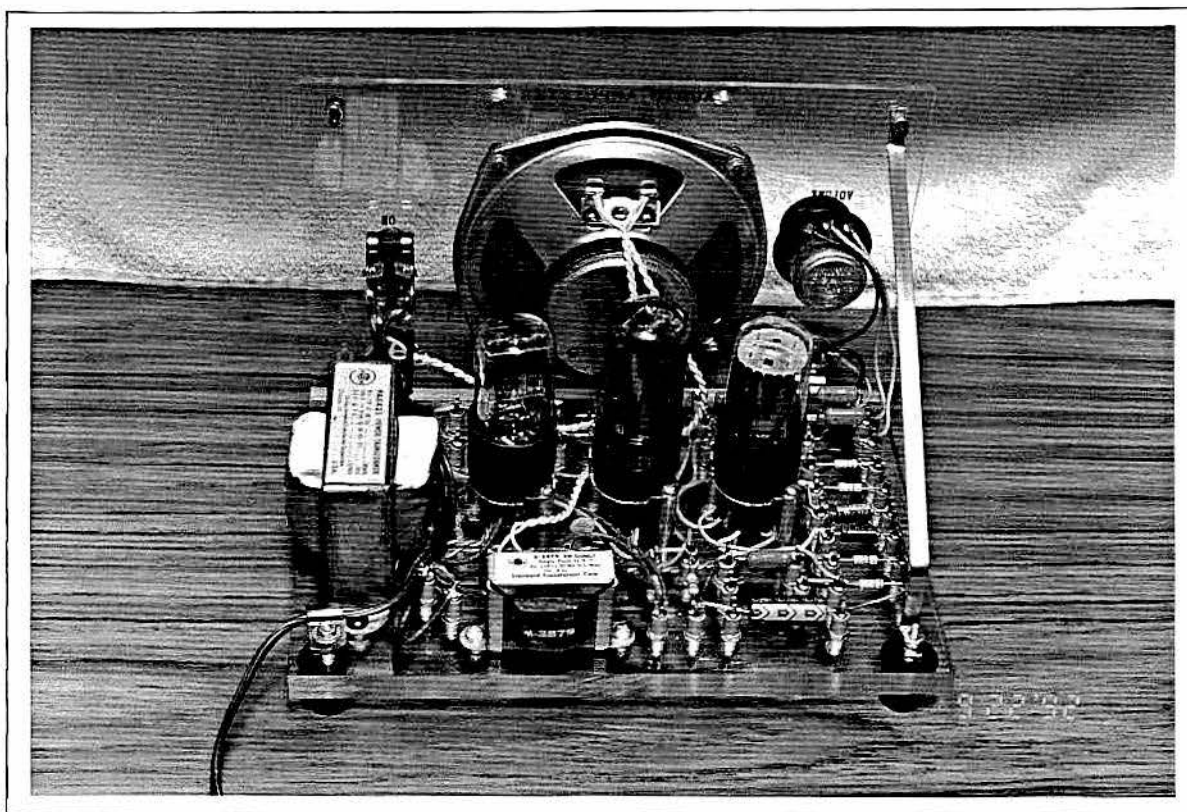
Front view of the audio amplifier. The speaker is a Radio Shack 40-1240D 5" round replacement speaker.

The following are some of the highlights and comments about the completed amplifier:

- \* The input uses a fairly standard 6SN7 resistance-coupled amplifier circuit. The 6SN7's cathodes, pins 3 and 6, were left unbypassed and some negative feedback was introduced into the first stage to lower the overall gain and distortion percentage. The measured THD% with a nominal 68K negative feedback resistor was 1-2%. The 68K was determined experimentally using an HP 331A Distortion Analyzer.

\* The power supply uses a half-wave-connected 6X5 with a Stancor PA-8421 xfmr with 125VAC @ 0.05A and 6.3VAC @ 2A secondaries. The output of the supply measures 158V to the 6V6 and 134V to the 6SN7. The zero-signal 6V6 cathode current is 18mA and the 6SN7 requires 1mA.

\* The output of the 6V6 is coupled to a Radio Shack 40-1240D 5" rnd replacement speaker using a Stancor A-3879 single-plate to V.C. output xfmr (10K $\Omega$  pri to 4 $\Omega$  sec).



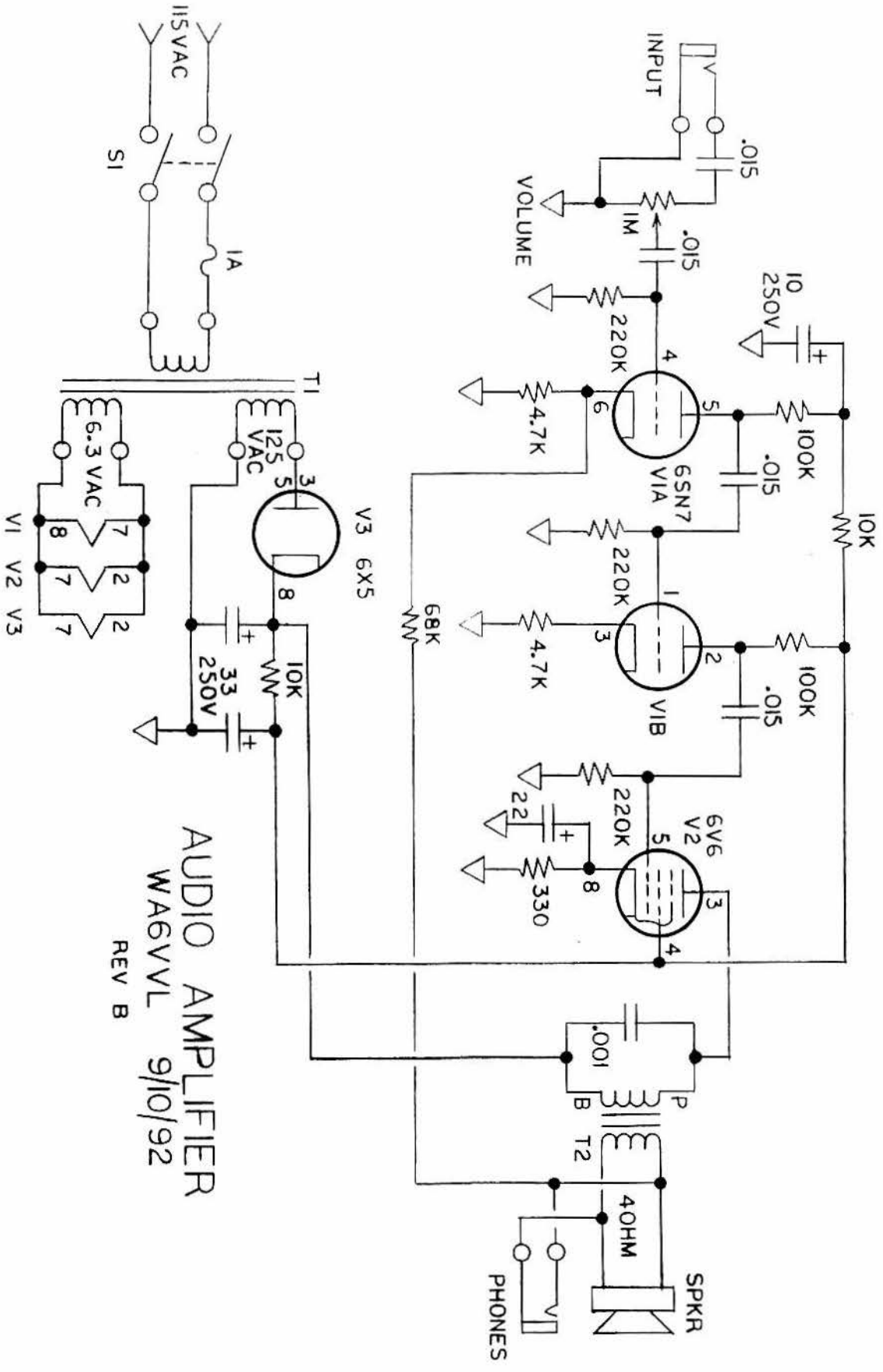
Rear view of the audio amplifier. The tubes are, right-to-left: 6SN7, 6V6, and 6X5.

This article was written 9/92 and originally appeared in Electric Radio, Oct.'92, Issue #42, "Regeneration Fever", pgs. 20-24.

#### Selected References:

1. RCA Receiving Tube Manual, Technical Series RC-23, 1964.

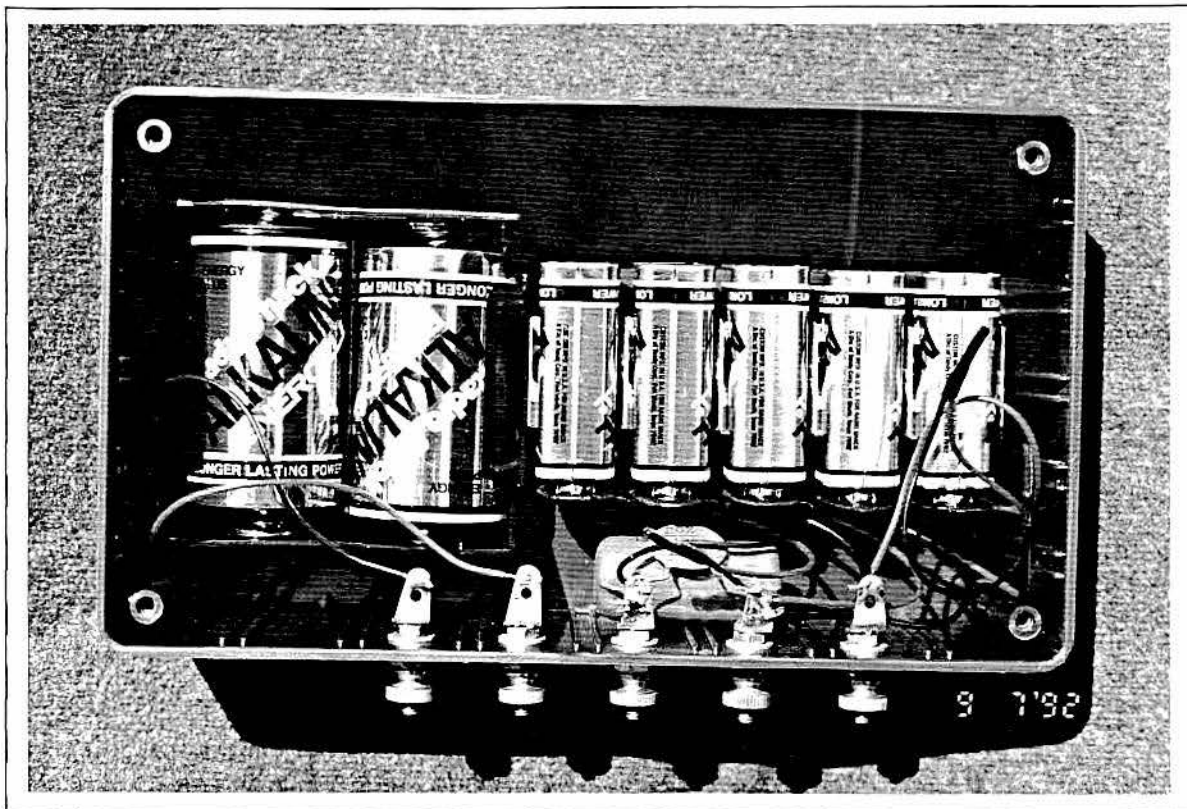




AUDIO AMPLIFIER  
WAGVL 9/10/92  
REV B

- - - 30-30 BATTERY PACK - - -

When I was designing my 30-30, I had always intended to power it from A and B batteries. I was going to use a couple of the large 1-1/2V batteries for the filaments and (say) a couple of 45V batteries for the 45V and 90V supplies for the detector and audio stage. Boy, what a shock when I called the local battery supplier - for two Neda type 905/Eveready IS6 (1-1/2V) and two Neda type 201/Eveready 455 batteries they wanted \$64!!!! At that price, I didn't even call around!



Top view of the 30-30 battery pack with the cover removed.

To make a long story short, I went to Radio Shack and put together a battery pack that uses two "D" cells and five 9V batteries:

- \* The battery pack supplies 3V for the filaments, 18V for the detector, and 45V for the audio stage. I used five Radio Shack 270-326 9V battery holders and one 270-386 dual "D" holder to mount the batteries.

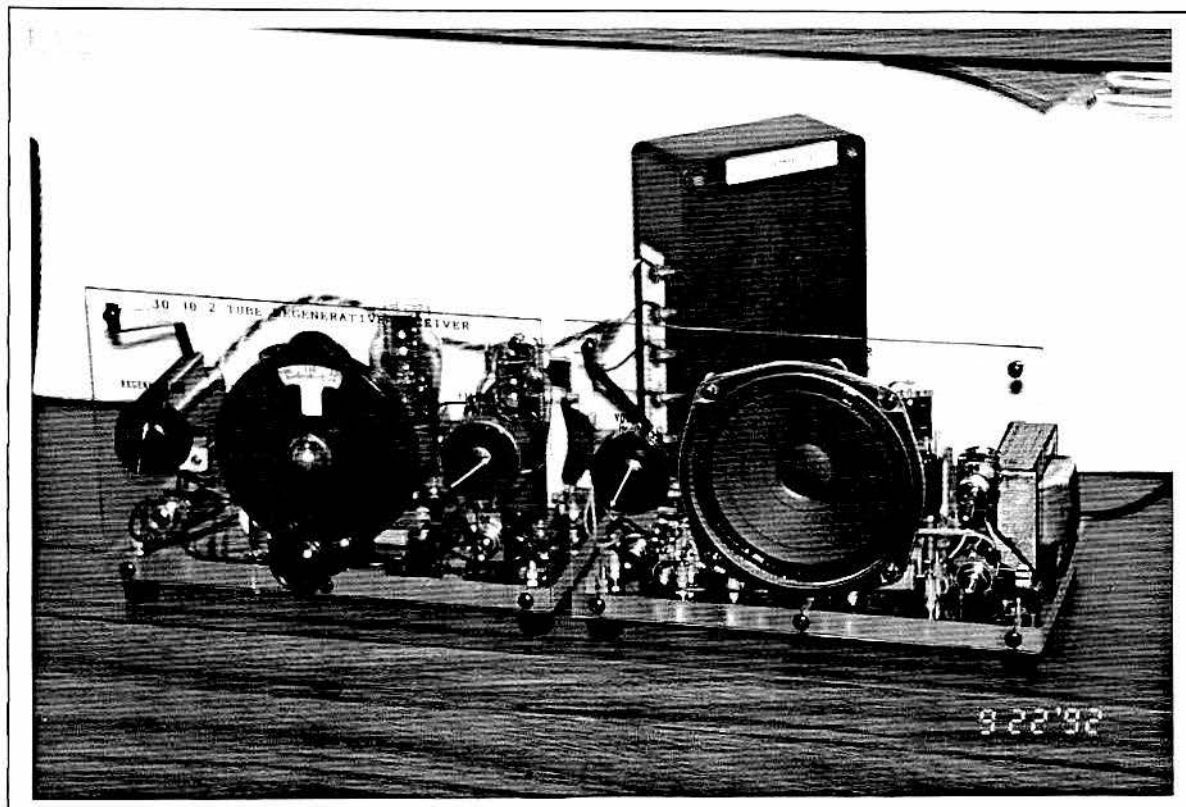
- \* It is built into the Radio Shack 270-224 7-1/2" x 4-1/4" x 2-1/4" low-cost plastic enclosure.

- \* The output terminals were made using 8-32 brass hardware to match the 30-30 receiver.

- \* With a strong AM station tuned in, the detector draws 0.4 mA and the audio stage 3.3 mA w/2K $\Omega$  headphones. The filaments draw approximately 120 mA. Battery life should be very acceptable.

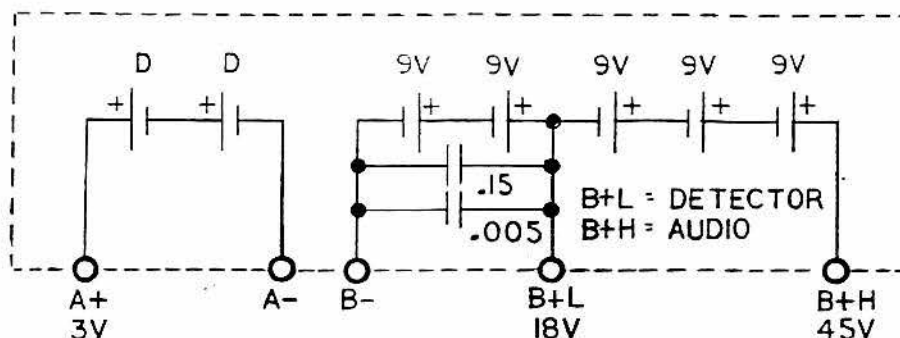
I bypassed the 18V supply with a 0.15mfd and 0.0047mfd to keep the audio out of the detector as the batteries age and their impedance increase. So far, the battery pack has worked OK and I don't expect any problems. I have a total of \$24 invested in the battery pack and new alkaline batteries should run less than \$12 - a far cry from the original \$64.

I don't disconnect the battery pack from the 30-30 receiver - I just turn off the filaments.



The 30-30 battery pack behind the 30-30 receiver and audio amplifier.

This article was written 9/92 and originally appeared in Electric Radio, Oct.'92, issue #42, "Regenerative Fever", pgs. 20-24.

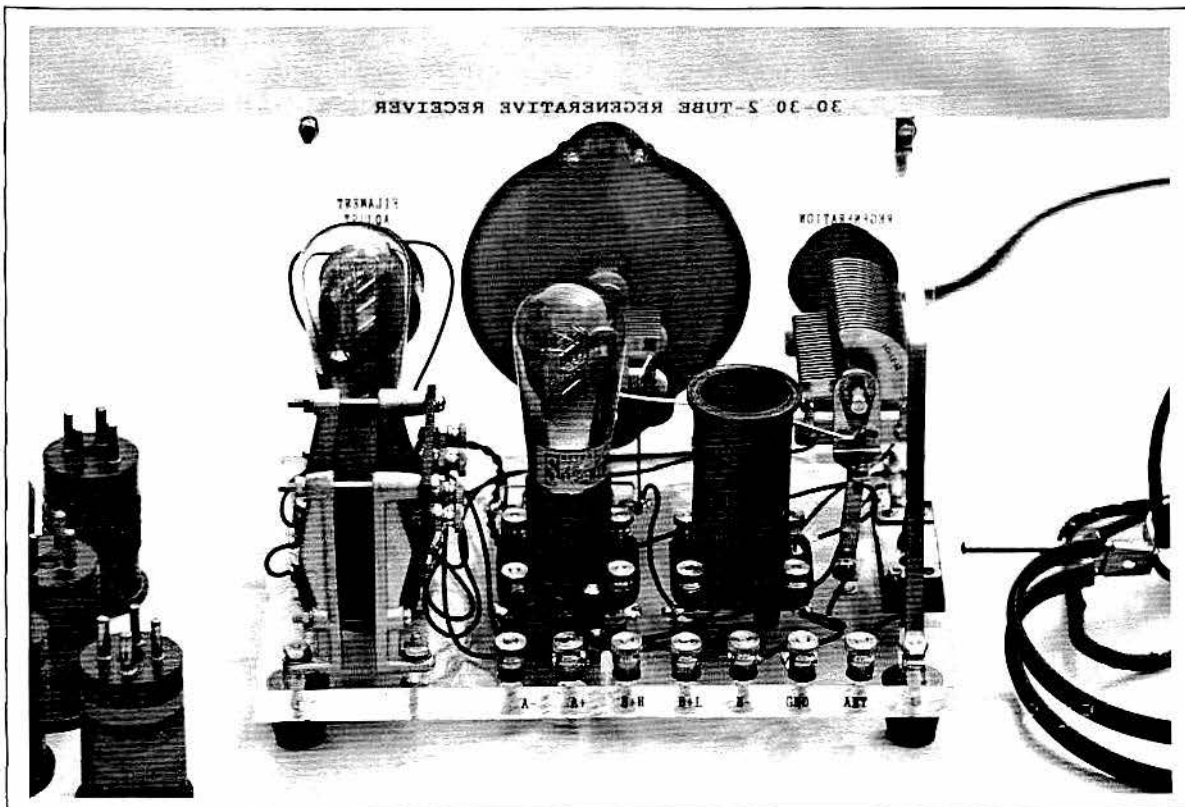


30-30 BATTERY PACK  
WA6VVL 9/2/92

- - - NOTES ON WORKING WITH PLEXIGLASS - - -

1. The plexiglasses' protective cover allows you to dimension and drill very accurately.
  - \* Use a scribe to center punch the holes instead of the larger automatic center punch.
  - \* Use a small pilot drill (say #60) to pre-drill all the holes. Go up in steps to drill the larger 3/8" holes.
2. I have had the best success with relatively slow drill speeds. 690 and 1100 RPM have both worked OK (the plexiglass manufacturer recommends a higher speed and modified drill bits).
  - \* Drill slow enough not to melt the plastic. Drill bits will get very hot. You will be able to see the material "flow" if you get in a hurry. If you are not sure, experiment on a piece of scrap plexiglass.
  - \* I don't clamp the panels for 3/8" and smaller holes but I firmly hold onto the panels when I drill them. A drill that "catches" will ruin a front panel! If your not sure, clamp it!
3. Tapping the 8-32 holes goes much quicker if WD-40 is used as a thread cutter/lubricant. Just coat the tap with a quick squirt before each hole is tapped.
  - \* If you choose NOT to use WD-40, run the tap slow enough so that heat build-up doesn't melt the plexiglass. You will be able to see the material "flow" if you run the tap too fast and the quality of the tapped hole will suffer. The best solution is to use the WD-40!!!
  - \* Don't use the recommended tap drill. The recommended drill for an 8-32 tap is a #29. The #29 did not provide adequate threads so I used a 1/8" drill. You may want to experiment on a piece of scrap plexiglass before making a final decision.
4. I used a circle cutter to cut the 4.2" speaker hole and the 2.2" meter hole. I have never gotten over my "fear" of using these things so I am always very careful.
  - \* Use a drill-press. Do NOT use a hand drill! The circle cutter I use specifies a maximum safe speed of 500 RPM. The drill press I used has a minimum speed of 690 RPM. 690 RPM caused no apparent problems.
  - \* Use a sharp cutting bit.
  - \* Clamp the panel with at least two C-clamps. Make sure that the circle cutter clears the C-clamps all the way down.
  - \* I cut the panel from both sides to make sure that the back-side doesn't chip or crack.
5. I use a T-handle reamer to enlarge the 3/8" hole to 15/32" for the toggle switches. I take my time and just take easy cuts with the reamer - it just seems a tad "safer" than using a 15/32" drill bit.

6. Annealing plexiglass at elevated temperatures reduces the internal stresses created during the fabrication process. Since most of us will NOT anneal the finished panel, it is very important **NOT** to expose the finished panel to solvents (e.g., cleaners, thinners, paints (like Krylon), or....) or **immediate crazing/cracking will result.**



Rear view of the 30-30 regenerative receiver. The only tapped holes are the three 8-32 holes that mount the front panel to the base. Most of the remaining holes are 6-32 and 8-32 through-holes. The 1/8" front panel is too flexible and requires the one-piece brass stiffener AND brass U-bracket.

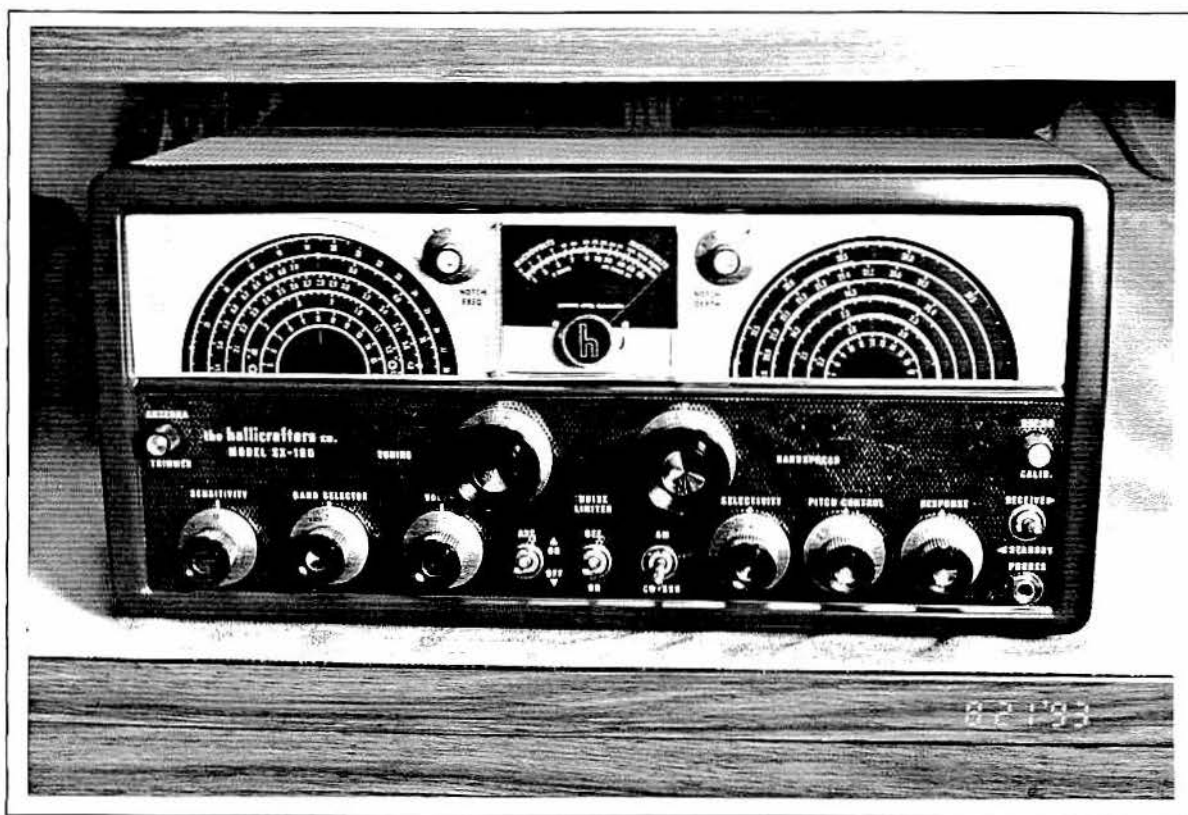
This article was written 9/92 and originally appeared in Electric Radio, Nov.'92, issue #43, "Notes on Working with Plexiglass", pg. 23.



- - - THE HALLICRAFTERS SX-100 - RESTORING A CLASSIC - - -

Dave Mills, AJ70, has rebuilt, cleaned up/repainted, and restored, lots of vintage equipment. Since he used to live only 7 miles from my QTH, I had many opportunities "to look over his shoulder" at his handi-work. It was while he was going through the Hallicrafters S-85, SX-96, and finally an SX-100, that I developed an interest in the SX-100. The more I played with his SX-96, and later his SX-100, the better I liked them. It wasn't that I had a bad opinion of the SX-96/SX-100 - I had NO opinion - I didn't know anything about them! But I was learning fast!

I visited w/John Hurst/KU6X in November '92 and he showed me his primo SX-100. I was now "hooked" and started advertising for one. I physically looked at about seven or eight and called on about six more before Dave Kamlin/AB6XK found a nice one at the July '93 Flagstaff swapmeet. He gave me the option of buying it and I did.

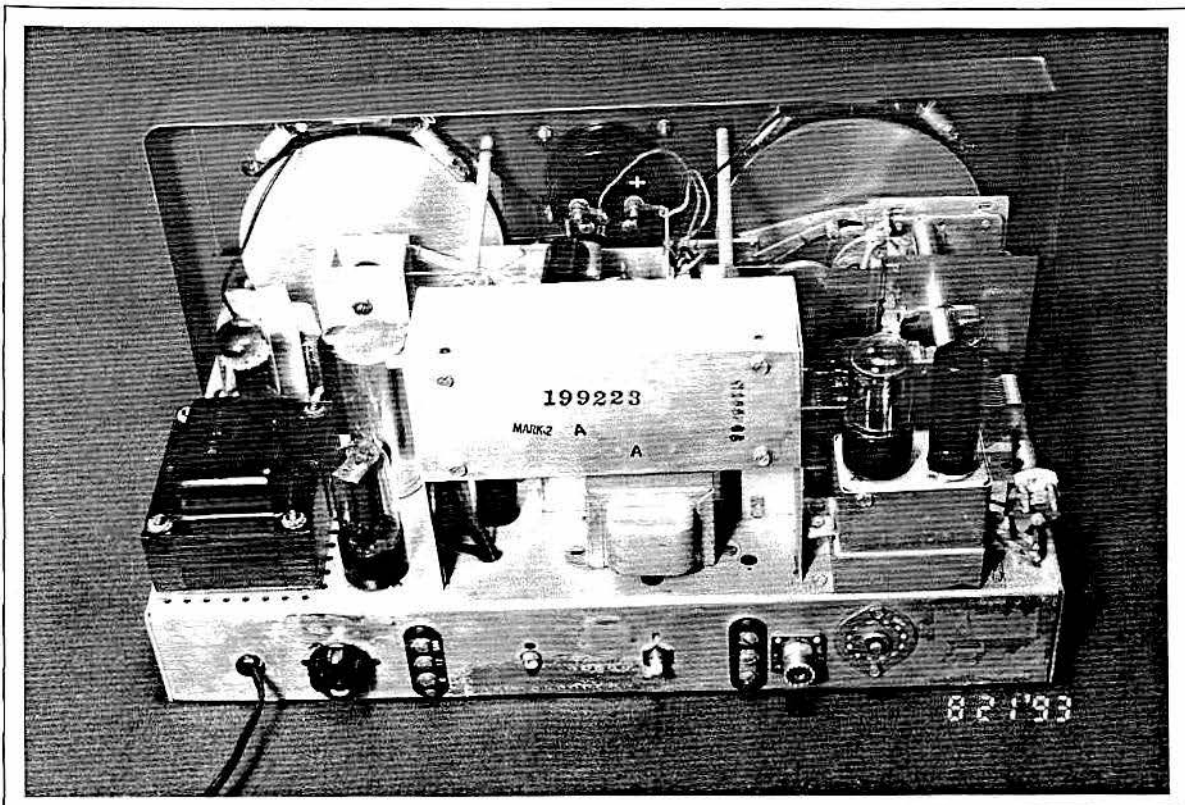


Front view of the Hallicrafters SX-100. This is a late model with SX-111 type knobs. This general coverage, 14 tube rcvr, sold for \$295 during the years it was manufactured - 1955 to 1963.

The Hallicrafters SX-100 is a 14-tube dual conversion general coverage superhet rcvr that tunes from 538-1580 KHz and 1.72-34 MHz in four bands. Calibrated electrical bandspread covers 80-10M. First and 2nd IF's are 1650 and 50.75 KHz respectively. The



SX-100 sold for \$295 and was available from 1955-1963.



Rear view. The octal sized "tube" on the far right is the 100KHz calibration crystal.

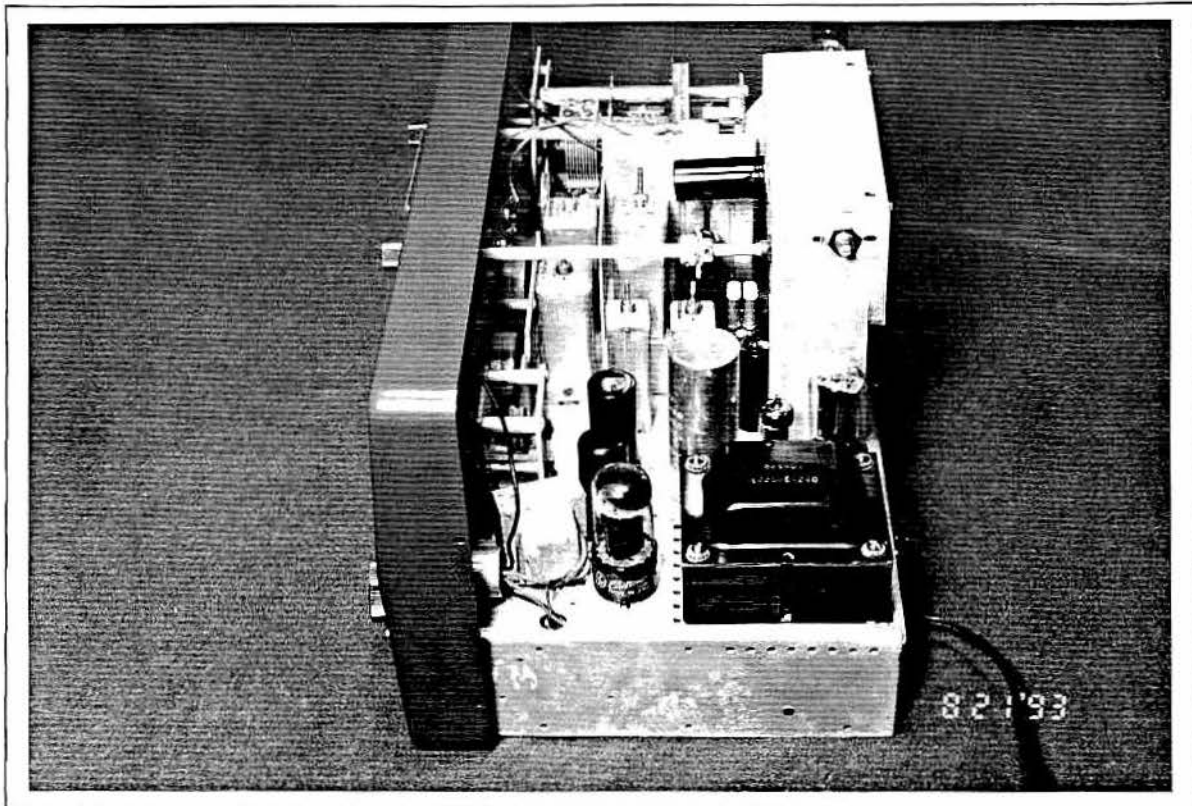
Some of the more salient features of the SX-100 are:

- \* tuned RF stage w/front panel ANTENNA TRIMMER.
- \* double-conversion on all bands.
- \* adjustable selectivity from 0.5-5 KHz.
- \* switched dual crystal-controlled 2nd conversion oscillator for precise LSB/USB tuning.
- \* notch filter w/adjustable NOTCH DEPTH and FREQ.
- \* precision gear drive tuning mechanism.
- \* built-in 100 KHz xtal calibrator w/front panel CALIB. OFF/ON switch.
- \* front panel STANDBY/RECEIVE switch. The rcvr can also be disabled via the DC POWER SOCKET on the rear apron of the rcvr.
- \* front panel ON/OFF AVC switch. In the AVC position, the AVC time constant is changed with the AM/CW-SSB switch, increasing in the CW-SSB position to provide better AVC action for SSB reception.
- \* large 3-1/4"W x 2-1/2"H S-meter.
- \* front panel phone jack

Mechanically, the SX-100 looks like the culmination of a multi-generational project, from SX-76 to SX-96 to SX-100. The notch filter, 2nd conversion oscillator, and 100 KHz calibrator assemblies are all mounted on top of the chassis and all look like

after-thoughts, giving the top of the chassis a very "cluttered" look. The overall dimensions of the SX-100 are 8-7/8"H x 18-1/2"W x 11"D.

Cosmetically, the Hallicrafters SX-100 is classic vintage amateur radio.



Side view. The two 2nd conversion oscillator crystals are visible above and to the right of the electrolytic filter.

My SX-100 is a Mark-2 model. Based on the date-codes on the original Hallicrafters tubes (60-41, 60-49,...) and crystals (10/61 & 11/61), I think this rcvr was originally sold as early as '62. The knobs are the latest "SX-111 type" as pictured in the '63 ARRL Handbook, the last year the SX-100 was advertised in the Hdbk. The chassis is corroded but is still one of the better ones that I have seen.

I brought the SX-100 up on a variac and to my surprise, everything worked! The dial calibration was way off but "came back" after using it for a couple of weeks. I checked all tubes and all were OK. After two weeks of use, I used an HP 606B to align it. The IF's were really off, especially the 50.75 KHz IFs. It took a couple of evenings to get it right but the difference in performance was worth the extra time.

Dave Mills loaned me his 2nd SX-100 "parts unit" to upgrade some of the parts. The corroded tube shields were sanded and painted

black and the chassis cleaned.

At this point, I decided that the SX-100 would be a "keeper". The front cowling and cabinet were badly scratched and I decided to have them professionally repainted. I have repainted a lot of my gear but one thing that I have noticed is that the finishes have been relatively soft - they're not very tough/durable and will easily scratch. I removed the cowling, hinged top cover, and cabinet and lightly wet sanded the surfaces, feathering the edges of the scratches. I masked the tube location chart on the inside of the cabinet and then let a local firm, Custom Enamelers, paint it. It cost \$100 to paint the three pieces with two colors. Custom Enamelers did a very good job matching the finish and color of the original cabinet. I waited a few days for the paint to "cure" and then very carefully put everything back together.

Was it worth it? I think so. The SX-100 works very well and I really enjoy using it with my various CW xmtrs on CW QSOs. I use it on the weekends to listen to the 40M SSB swapnets and while not as stable as my 75A-4, it's "good enough".

The matching Hallicrafter's R-47 speaker is adequate for CW and SSB reception with an advertised flat response from 300-2850 Hz.

This article was written 11/93 and originally appeared in Electric Radio, Feb.'94, issue #58, "The Hallicrafters SX-100, Restoring a Classic", pgs. 14-15.

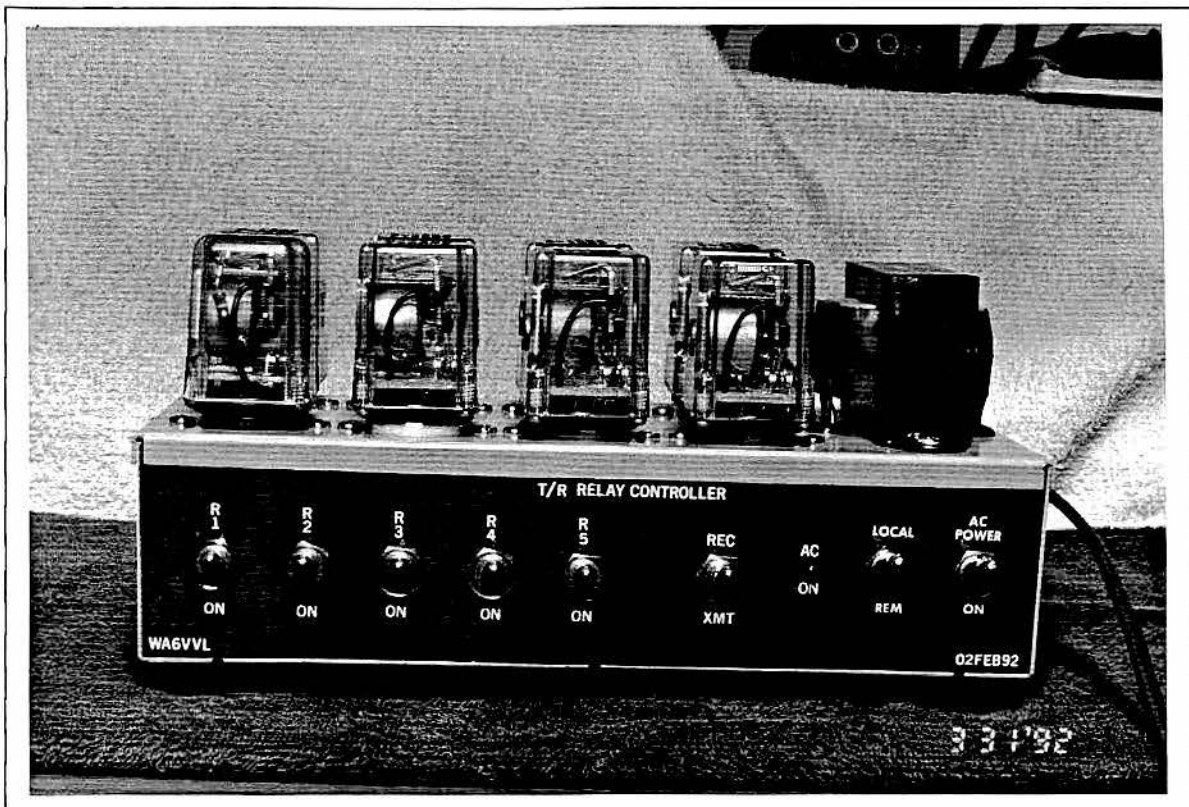
Selected References:

1. "Recent Equipment - The Hallicrafter's SX-96 Receiver", QST, June '55, pgs. 42-43.
2. "Recent Equipment - The Hallicrafter's SX-100 Receiver", QST, Dec.'55, pgs.52-53, 180.

- - - 5-POSITION T/R RELAY CONTROLLER - - -

Now that I have collected a fine stable of vintage receivers, I was going to buy a 5-position (or so) antenna switch so that I could use them. When I connected my 75A-2 and DX-40 for my first AM QSO since '62, I realized that a simple antenna switch was **NOT** going to cut it!

As a result of that (brief) experience, I designed and built the **5-Position T/R Relay Controller** shown in the enclosed photos and schematic. Even though I used my "junk" box and bought most of the parts at swapmeets, I still managed to spend \$60 on this project!



Front view of the T/R Controller.

The design of this controller, both electrically and mechanically, was based on finding surplus NIB Potter & Brumfield KRP11A 24VAC DPDT relays for \$1 each - the controller uses seven. Even though I wanted to use octal-type relays, I was not willing to pay the \$13.60 each for new relays (Newark's '90 Catalog, #111). Finding these relays was a major step in the design and construction of this controller. I used a 10"L x 4"D x 2-1/2"H LMB No. 144 chassis box to build the controller.

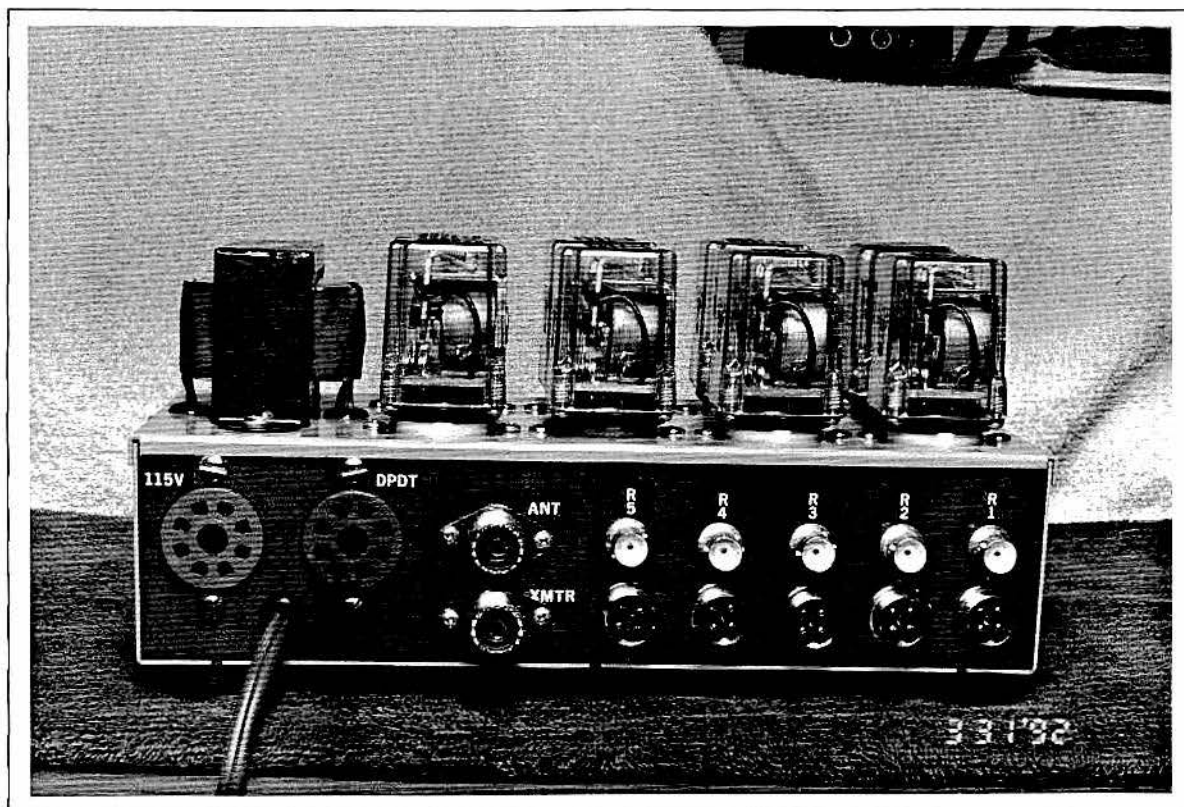
The following are some of the highlights and comments about the completed controller:

\* The "power supply" for the controller uses a Triad F40X 26.8VAC



@ 1A filament xfmr. 100 ohm 2W resistors in series with each 24VAC coil drops the coil voltage. Since the relays are AC, no rectifier and filter components are required. I would have used a Triad F46X 24VAC xfmr (or equiv) but the F40X was "free" and required the additional dropping resistors for the coils. Two Radio Shack 270-1238 5x20mm in-line fuse holders with 1A fuses were wired inside the chassis on the primary side.

\* There are 5 switched positions with individually isolated SPDT rcvr muting contacts and BNC connectors for the antenna. I used Radio Shack 274-002 4-pin panel-mount mic sockets for the rcvr mute connectors. The mating plug is a 274-001.



Rear view.

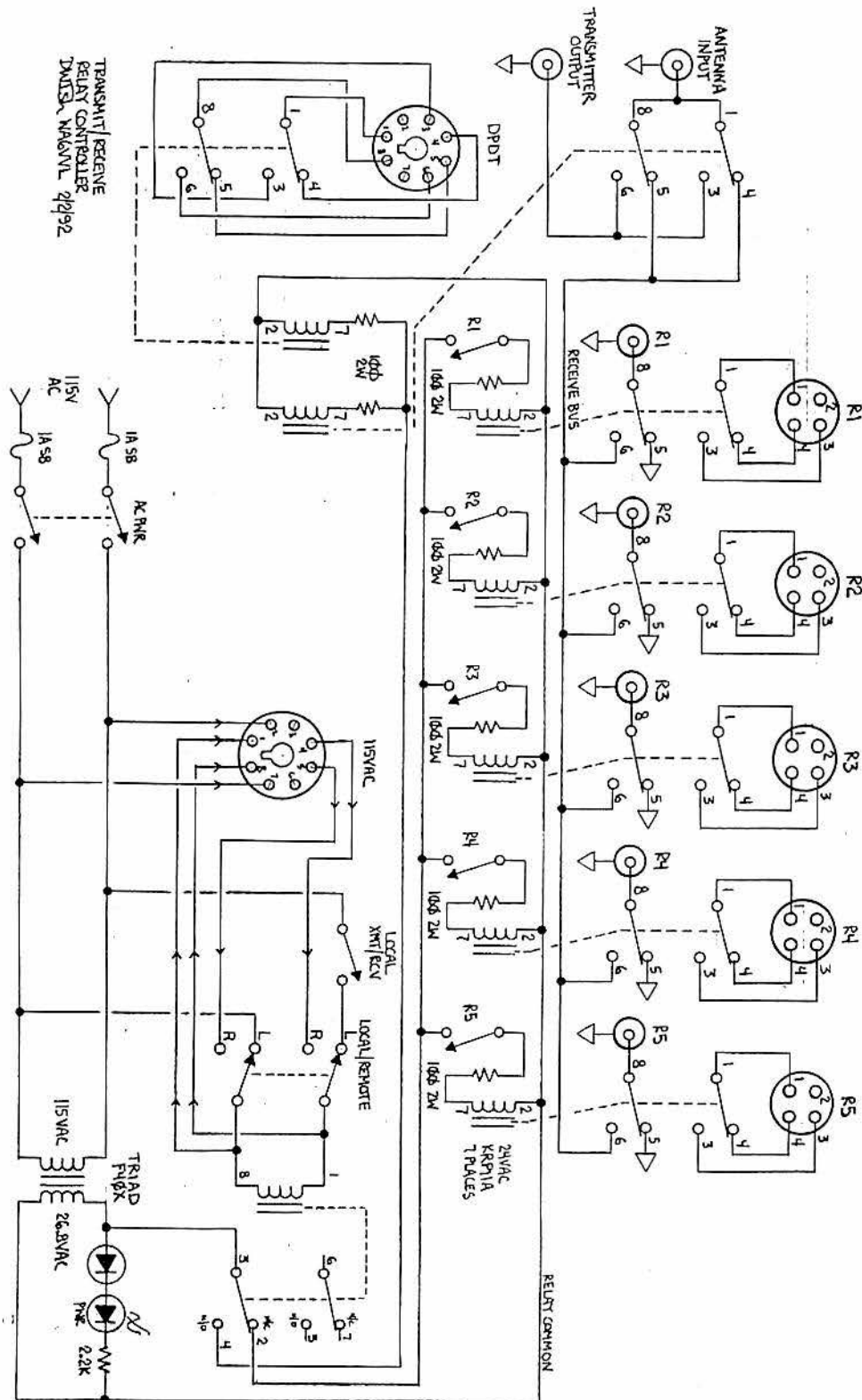
\* Built in XMTR antenna switching is included. I have successfully switched my Viking I and Challenger, DX-20, DX-40, and homebrew 100W 6AG7/1625 CW xmtr. SO-239 connectors are used for the antenna and xmtr.

\* A separate set of auxiliary DPDT contacts is available for external control applications. The auxiliary relay is in parallel with the antenna T/R relay.

\* Local/Remote capability was added to increase the flexibility of the controller. A 115VAC relay was used for the main T/R relay. 115VAC from the controller can control an external 115VAC T/R coaxial relay. In the local mode, the front panel REC/XMT switch controls the controller. In the remote mode, 115VAC from my DX-40, Viking I, or remotely mounted T/R switch controls the controller.

I now use the controller to switch antennas between a 75A-4, SX-100, 75S-3, HQ-110, and an R-388. Side-by-side comparisons of rcvrs is now much easier to do, especially on-the-air tests that require rcvr muting. Two rcvrs can be selected simultaneously, but it tends to reduce signal strengths.

This article was written 7/92 and originally appeared in Electric Radio, Aug. '92, issue #40, "5-Position T/R Relay Controller", pgs. 32-33.

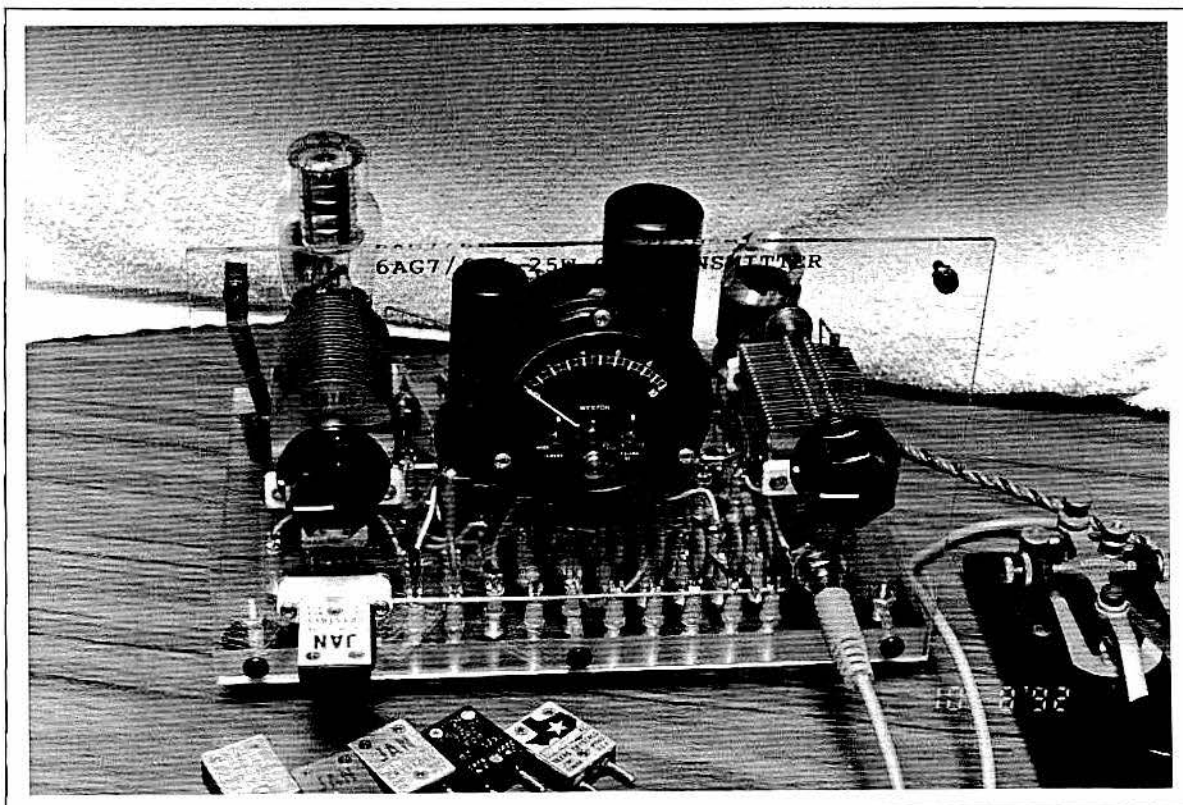




- - - 6AG7/6L6 25W CW TRANSMITTER - - -

As I was collecting parts for my 30-30 2-tube regenerative receiver, I was planning a matching 1-tube 80/40M crystal controlled CW transmitter. I already knew which one - the 1-tube 6AG7 xmtr described by Lewis McCoy/W1ICP in the November, 1953 issue of QST - the first xmtr that I built in 1959. This xmtr was featured in several of the later 50s ARRL Handbooks.

Well, so much for advanced planning!! After several conversations with Barry, N6CSW, at Electric Radio, he persuaded me to use a 2-tube version "in case I ever wanted to AM modulate it". I could then build a matching AM modulator!

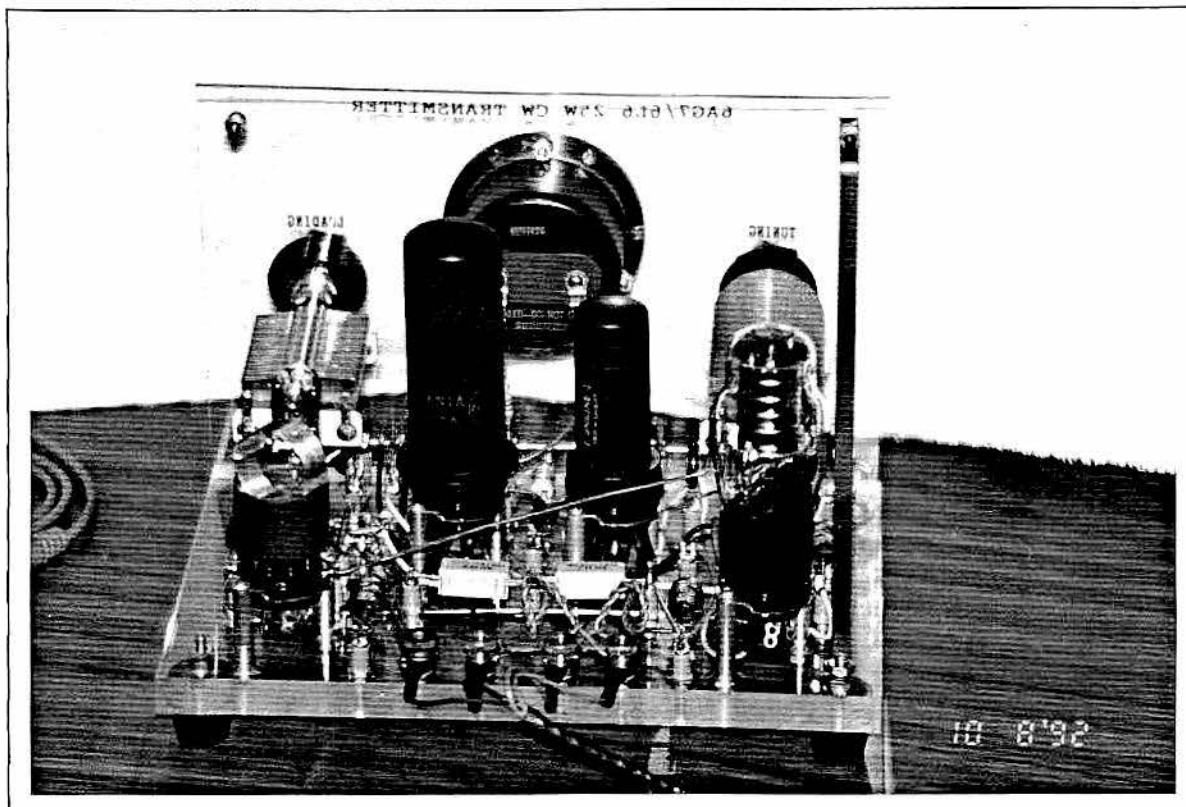


Front view of the 6AG7/6L6 xmtr.

I was still going to use the 6AG7 oscillator, but what "final" should I use? I considered the 1625 (I had a "box" full), a second 6AG7, an 807, a 2E26 or 6146, but I finally settled on the "classic" 6L6 - the original metal version released in 1936. As pointed out in Jim Musgrove/K5BZH's article "The Pioneering Novices" (ER#41), the 6AG7/6L6 crystal controlled xmtr was a favorite novice xmtr of the 50s. In addition, the 6AG7/6L6 combo can be found in many amateur handbooks from the 50s and 60s. There is no need to re-invent the "wheel" - just browse through your vintage library. I kept the design as simple as possible.

Like the 30-30 and its matching audio amplifier, the xmtr is built

using 6" x 9" plexiglass for the base and front panel. Laying out the parts placement for the xmtr proved to be the toughest job! It took me four tries to get it "right" - a couple of nights work.



Rear view of the xmtr. The tubes are, right-to-left: OD3, 6AG7, and 6L6. Brass shimstock is used to stiffen the front panel.

The following are some of the highlights of the xmtr's design:

- \* The 6AG7 crystal oscillator is of grid-plate configuration and is straight from the ARRL handbook. The plate circuit is untuned. Lewis McCoy/W1ICP pointed out in his January, 1953, QST article "A Novice 35-Watter" (1955/56 ARRL handbook) that the 6AG7's plate RF choke must be broadly resonant at 5 MHz to provide sufficient drive to the 6L6 on 80/40M. He recommended a 100 uH RF choke, a Millen 34300. I have not found that RFC yet and as a result, the 2.4 MH RFC that I used does NOT provide adequate drive to the 6L6! Result? 5W output!

- \* The oscillator's plate and screen supply is regulated with an OD3/VR-150. The 6AG7's plate and screen current is approximately 9 mA.

- \* The 6L6's pi-network was designed using two 310 uufd variables. The 40M coil uses 15T of B&W 3016 miniductor stock (1" dia., 32TPI). The coil is mounted in an octal tube base. I have also been using this coil for 80M operation. A fixed capacitor can be installed from pins 2 to 3 of the octal coil form to optimize loading if the 310 uufd loading cap isn't adequate.

\* The 6L6's plate current is monitored by a 0-100 mA 2½" meter. A 0-1 mA movement is used with the appropriate scaling resistors. The scaling resistors were selected on the bench prior to assembly. A 0-150 mA meter might have been a better choice as the 6L6's plate current is 80 mA at 300 VDC.

\* The cathode/key-click circuitry was "borrowed" intact from the 40M 6AG7/6L6 Novice Rig featured in "104 Ham Radio Projects for Novice & Technician" (TAB Book by Bert Simon/W2UUN - lots of "glow in the dark" circuitry).

\* I kept the same front panel symmetry as the 30-30 and the audio amplifier.

The power supply requirements are 1.6A @ 6.3 VAC and 105 mA @ 300 VDC (130 mA @ 350 VDC). I have been using a Heath IP-17 power supply for both testing and operation.

My first QSO with the 30-30 receiver and 6AG7/6L6 transmitter was on 40M with Bill Brannick/KC6SZE. This was my first QSO using a completely homebrew station. My second 40M QSO with the 6AG7/6L6 was with Dave Mills/AJ70. He gave me a 539 and reported that the xmtr's keying and tone were OK...

This article was written 10/92 and originally appeared in Electric Radio, "6AG7/6L6 25W CW Transmitter", Nov.'92, issue #43, pgs. 20-22.

#### Selected References:

1. "The Junk-Box Jewel", C.W.Gwyn, W4QAG, CQ Magazine, Nov.'52, pgs. 45-48.
2. "A Beginner's 35-Watt Transmitter", The Radio Amateur's Handbook, 32nd Edition, ARRL, 1955, pgs. 158-159.
3. "Novice Transmitter - Using Printed Circuit Techniques", E.L.Klein, W4UHN, CQ Magazine, Apr.'57, pgs. 20-24.
4. "40-Meter Novice Rig", 104 Ham Radio Projects For Novice and Technician, Bert Simon, W2UUN, Tab Books, #468, 1968, pgs. 108-110.



- - - 5763 80/40/30M 10W TRANSMITTER - - -

Robert "Doc" Kurth/W5IRP answered my ad in ER for Ocean Hoppers and made me an offer I couldn't refuse. He said in part, "I will ship you 2 Ocean Hoppers.....for the following price - build me a 1 tube self-contained xmtr with built-in power supply,...".

This article describes a 1-tube 5763 80/40/30M transmitter that was built as a result of that "trade". The design is loosely based on the 1-tube 6AG7 xmtr described by Lewis McCoy/W1ICP in the Nov.'53 issue of QST. This design has been copied many times and was the first xmtr that I built in 1959. A 5763 version of this xmtr is described in "Easy-To-Build HAM RADIO PROJECTS" by Charles Caringella/W6NJV, 1967.



Front view of the 5763 80/40/30M QRP CW xmtr. The total cost of the xmtr was \$41. The green LED pilot light is to the left of the xtal socket.

The following are some of the highlights of the xmtr's design:

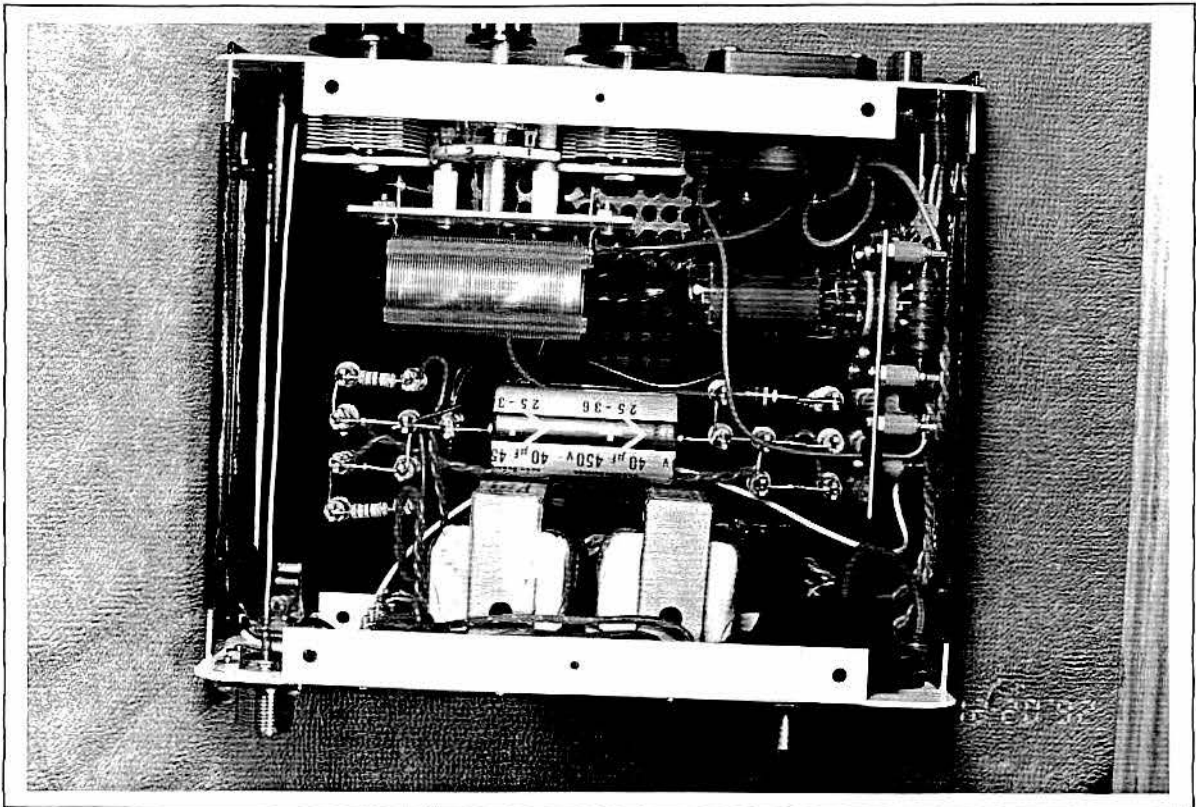
- \* Cabinets/sheet metal is getting harder to get and very expensive. One exception are the steel enclosures offered by EasyTech, Inc. in Fremont CA. The one I chose for this project is 2.5" x 8" x 7" (HxWxD) for \$12.95. The top and bottom covers are black painted steel. The front and rear panels are white painted (soft) aluminum. I am quite happy with the ease that this xmtr went together using this enclosure. I plan to build a 2nd xmtr



and other projects using this enclosure.

\* I don't know how I could have built this xmtr (and other projects) without having access to the TRW swapmeet! The total cost for this xmtr was \$41 and a huge percentage of the parts were purchased at TRW for \$0.10 to \$1. The 5763 bracket and xtal socket came from a DX-40 and the 5763 from an MT-1.

\* The tuning/load caps were purchased from Antique Electronics Supply and at \$3.90 ea (CV-235, 365uufd), were the most expensive parts other than the enclosure. Their size was perfect for this project.



Top view of the xmtr. The single 5763 is mounted on an L-shaped aluminum bracket. The secondaries of the two Stancor PS8415 power transformers are series/parallel connected. The coil has not yet been pruned to 42T in this photo.

\* I used the 5763 because I ran out of room for a 6AG7.

\* The 2" plate meter is for relative tuning only. However, full scale is approximately 62mA, so you can get a pretty good idea of actual plate/screen current. I bought several of these meters at a garage sale last year for \$0.50 ea. I didn't worry too much about a specific full scale calibration because the scale is non-linear..

\* The original McCoy design used a B&W 3016 inductor with 70 turns. I have had "problems" with 70T and this xmtr was no exception. I reduced it to 42T and tapped it accordingly for 40/30M operation.

\* The power supply is a tad unconventional in that it uses two

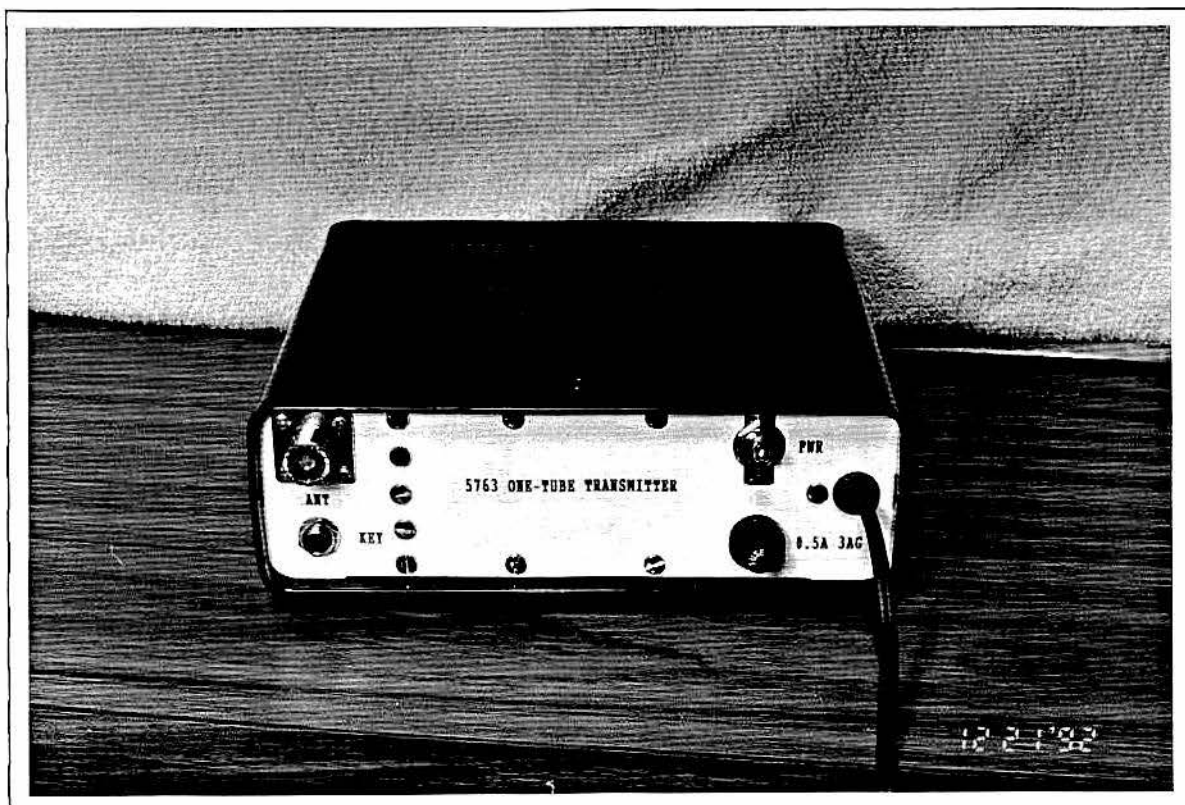


PS8415 Stancor xfmr's (these were \$1 ea @ TRW). The secondaries are series/parallel connected to provide 6.3VAC @ 1.2A and 250VAC @ 15mA. These xfmr's have a relatively small footprint and easily fit on the rear panel. The combined secondary rating is 11.3W. The 5763's filament draws 6.3VAC @ 0.75A or 4.7W. This leaves 6.6W margin for the xmtr. At a 50% duty cycle, 13.2W. Since this xmtr runs closer to a 25% duty cycle, I feel there is adequate margin in the power supply. The 40ufd 450VDC filter cap has 385VDC on it key-up, dropping to about 320VDC at 8-10W input key-down. I used a 1N4007 bridge with 22 ohm series resistors for the rectifier. A 270K 2W bleeder resistor discharges the filter cap when the power is turned off.

\* The connections from the front panel to the chassis & tube bracket are only tack-soldered - they are not wrapped. This makes it relatively easy to remove the front panel. I know, because I had to remove it several times as I optimized the number of turns on the pi-network inductor.

\* The power switch & key-jack were mounted on the rear panel to save front panel space. The power indicator is a green LED with a series 270 ohm resistor and diode connected to the 6.3VAC.

\* The front and rear panel lettering was done using a Brother P-Touch. I did this as an experiment. I have no idea how durable this labeling system is for amateur equipment but it looks **much** better than the old dymo tape labels!!



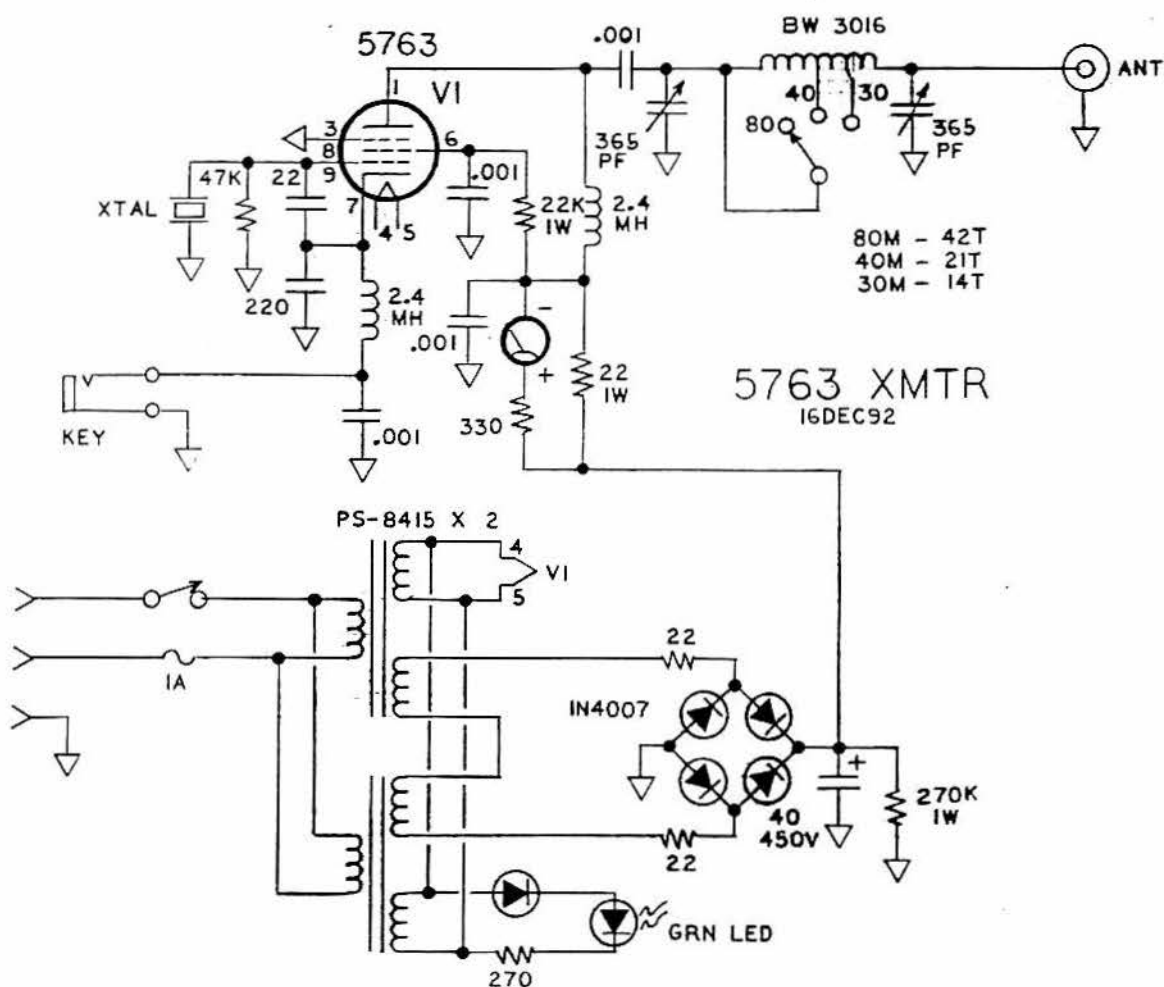
Rear view

The total time for construction was approximately 19 hours. I am "patiently" waiting for feedback from W5IRP as I work on the 2nd xmtr. I might use a larger 2.5" x 12" x 7" enclosure and add a "magic-eye" tube for tuning?

This article was written 12/92 and originally appeared in Electric Radio, Jan.'93, issue #45, "5763 80/40/30M 10W CW Transmitter", pgs. 9-11.

#### Selected References:

1. "Novice Transmitter for 40 or 80 Meters", Easy-To-Build HAM RADIO PROJECTS, Charles Caringella, W6NJV, First Edition, published by Editors and Engineers, Ltd., 1967, pgs. 15-28.
2. "RCA 5763 VHF Beam Power Tube Data Sheet", May '54.
3. "RCA Transmitting Tubes", Technical Manual TT-5, 1962.



- - - BUILDING A TWO-TUBE 6AG7 80/40M CW TRANSMITTER - - -

After building Robert "Doc" Kurth/W5IRP's 1-tube 5763 80/40/30M xmtr (ER#45), it worked so well I wanted to build one for myself. This article describes the construction of my 2-tube 6AG7 80/40M CW transmitter. The design is based on the 1-tube 6AG7 transmitter described by Lewis McCoy, W1ICP, in the November, 1953 issue of QST. This design has been copied many times and was the first xmtr that I built in 1959.

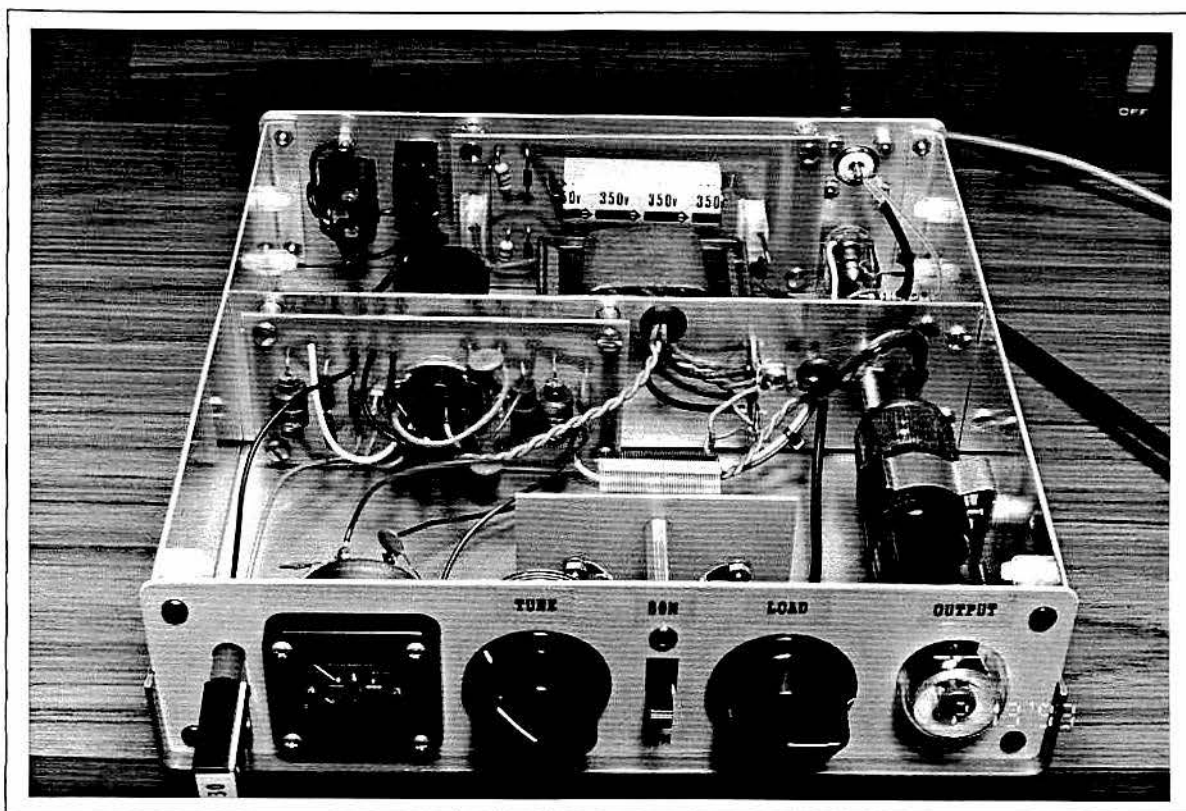


Front view of the 6AG7/6E5 80/40M QRP CW xmtr. The total cost to build this xmtr was \$75. Total construction time was 22 hours.

From the outside, the 6AG7 xmtr looks very similar to the 5763 xmtr described in ER#45. Even though there are some improvements in the electrical design (notably, the power supply), the significant differences are in the mechanical design of the xmtr. The following are some of the highlights of the transmitter's design:

- \* The 2-1/2" x 8" x 7" enclosure that I used for the first 5763 xmtr from Easy Tech, Inc. for \$12.95 is no longer available. That's really too bad because it was about the cheapest enclosure in the "known universe". After looking at alternate enclosures, I decided to use the Ten Tec CONSTRUCTO SERIES 2-1/2" x 9" x 9" BU929 enclosure. It's a bit pricey at \$37, but it is a very high quality enclosure. The box construction with an adjustable

height chassis plate offers design flexibility not possible with the cheaper enclosure. The BU929's larger size gave me sufficient room to add the 6E5 tuning indicator, use the larger 6AG7, and use a larger power transformer. The front and rear panels have a very durable baked enamel finish that did not flake/crack in spite of drilling, filing, chassis punching,....., etc. The modular nature of the BU929 allows you to build the xmtr in stages, much like a kit. The front panel, for example, can be layed out, drilled, punched, labeled, assembled, and wired in one day. The rear panel the next day, and so on. I used an internal 2-1/4" x 9" panel to mount the 6AG7 and power transformer and this panel was cut from the adjustable chassis plate supplied with the enclosure. I was quite impressed with the Ten Tec enclosure and, in spite of the price, will probably use it for other projects.



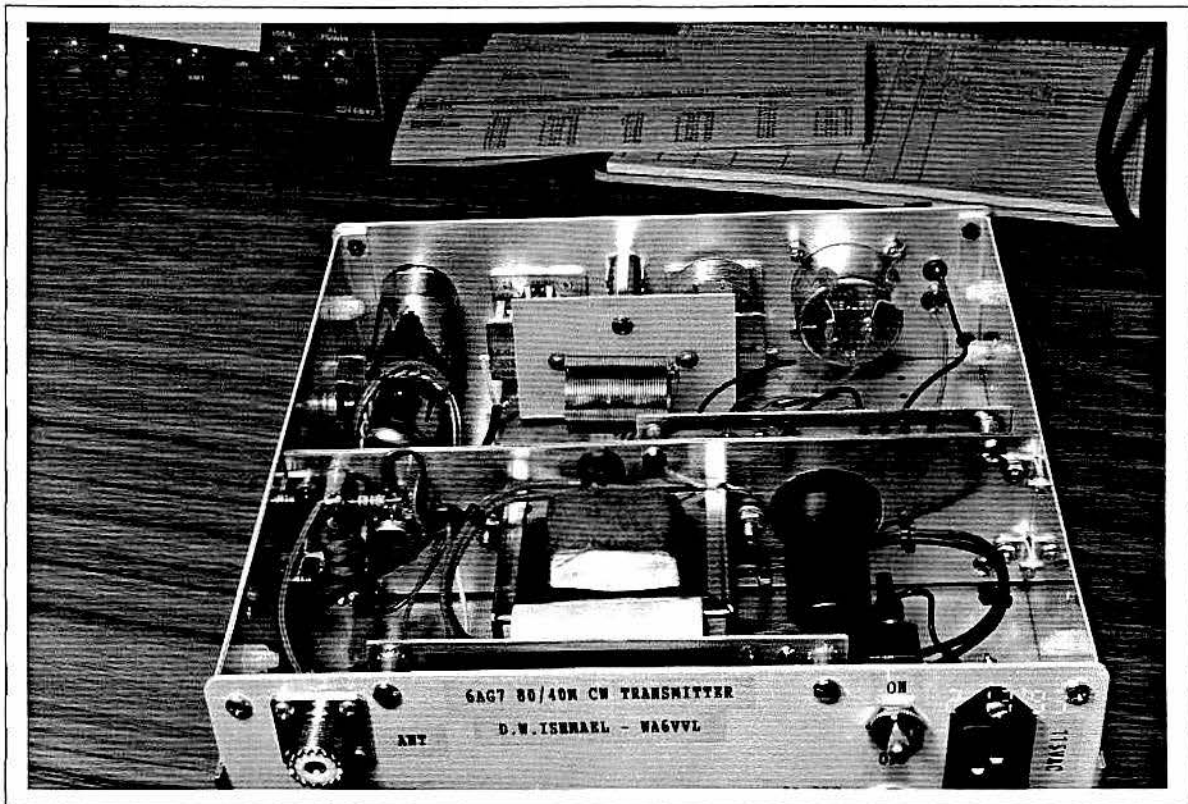
Top front view. Note the modular construction using the Ten-Tec BU929 CONSTRUCTO SERIES enclosure. The 6AG7 oscillator and power supply components are mounted on single-sided PCB's.

\* The front and rear panels were carefully layed out on a quad-pad. I didn't start the layout until I had all the parts. I made a copy of the quad-pad layouts and taped it to the panels as a center punching guide. I used a sharp scribe as a center punch instead of the automatic type because I can more accurately and consistently locate the holes with the scribe. After center punching, I used a small #60 drill (0.040") as a pilot drill. The next hole size was the 4-40 holes for the meter so I drilled all the holes with this drill also. It took a bit more time to



double- and triple-drill the panels but the accuracy is very good using this technique. One word of caution - not all copiers make 1:1 copies! Check the dimensional accuracy of your copies **BEFORE** center punching the panels!

\* All of the larger  $5/8"$ ,  $1-1/8"$ ,  $1-3/8"$ , and  $1-1/2"$  holes, were done with Greenlee chassis punches. I used a couple of pieces of paper between the chassis punch and the painted panels with the the cutter portion of the punch against the inside/non-painted side. The edges of the punched holes were quite satisfactory cosmetically with minimal "scuffing" of the paint. Holes up to  $3/8"$  were drilled. Holes from  $3/8"$  to  $1/2"$  were enlarged from  $3/8"$  with a T-handled reamer. I don't like to use drills larger than  $3/8"$  in soft aluminum - especially with hand-held electric drills.



Top rear view. The pi-network coil is 42T of B&W 3016 mini-inductor stock.

\* The power supply uses a Stancor PA-8421 xfmr with 125VAC @ 0.05A and 6.3VAC @ 2A secondaries. The Thordarson 26R38 or Triad R-30X xfmr will also work. I used a conventional full-wave voltage doubler circuit with two 47ufd 350V electrolytics at the output. Two 100K 1W resistors across these caps provide a bit of voltage equalization and bleeder resistance. I used 1N4007 rectifiers with 22 ohm series resistors. The combined secondary rating of the PA-8421 is almost 19 watts. With the 6AG7/6E5 filaments drawing 6.3VAC @ 0.95A or 6W, this leaves a 13W margin for the xmtr's plate and screen requirements - more than adequate.

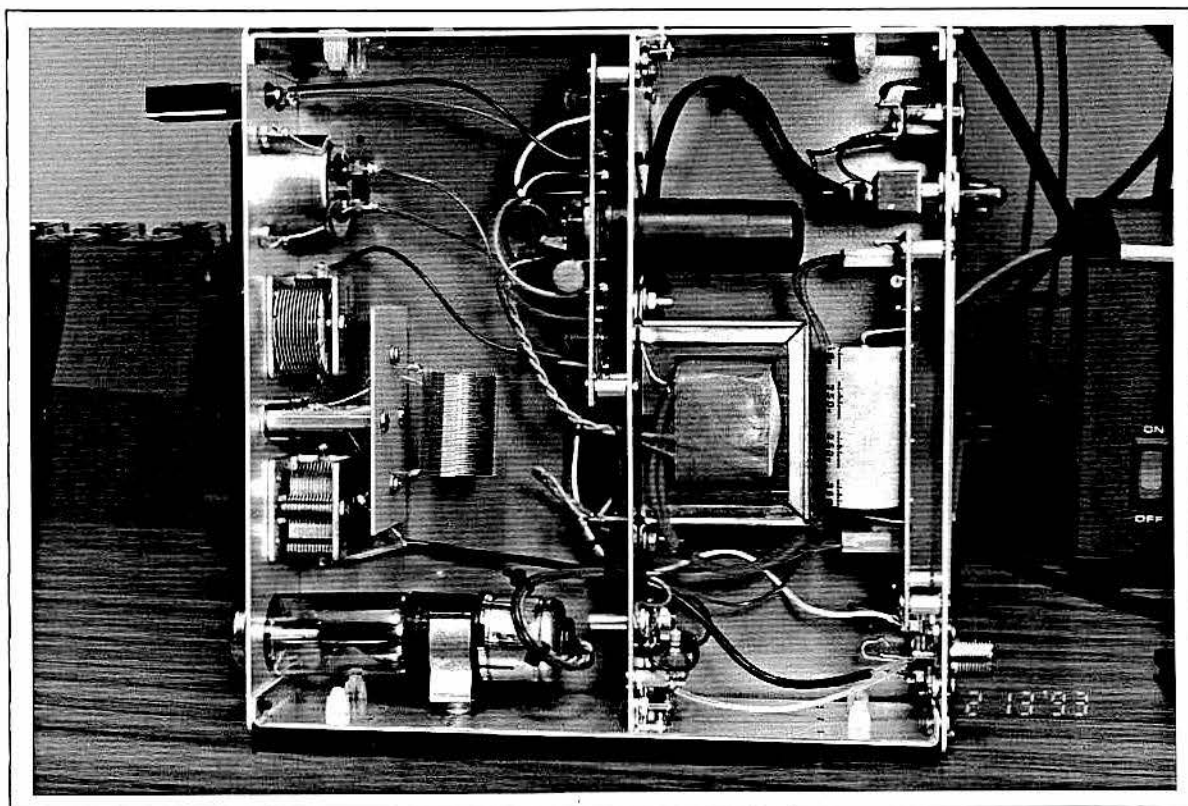
Even without ventilation holes in the enclosure, the xfmr is only warm after several hours of operation. The output voltage was 374 VDC key-up dropping to about 327 VDC at 8W input key-down. The low voltage tap on the voltage doubler provides 186 VDC to the 6E5/6U5 indicator tube key-up, dropping to 163 VDC key-down. The indicator tube dims a bit as the xmtr is keyed, but it's not objectionable.

\* The power supply/6AG7 circuit boards were made from GC Electronics pre-sensitized positive acting single-sided board material. They were layed out 1:1 on a quad-pad, taped on clear vinyl sheet protectors, and the artworks used to expose the boards. The boards were cut to size on a shear.

\* The tuning/load caps were purchased from Antique Electronics Supply in Tempe, AZ. Their P/N CV-235 @ \$3.90 each are just the right size for this xmtr with their 1" length. Even with an enclosure depth of 9", I still needed some relatively small plate tuning and loading caps.

\* As in the 5763 xmtr, I used 42T B&W 3016 miniductor stock for the pi-network coil, tapped at 21T for 40M. Since my xmtr was for 80/40M only, I used a slide switch for the bandswitch. I mounted the coil on a 2" x 3" piece of bare 0.062" PCB material and spaced it 1-1/2" from the front panel using 6-32 spacers.

\* The 2" 0-50 mA Phaostron meter monitors the 6AG7's plate and screen current.



Top view.



\* The 6E5 or 6U5 "magic-eye" indicator tube assures that the xmtr is tuned for maximum output. I used a 10K pot in the RF divider so that either 6E5 or 6U5 tubes could be used. The 6E5 takes about -7.5 VDC to close the eye while the 6U5 takes about -22 VDC. A fixed resistor could be used if only one tube-type is going to be used. I considered a small PCB for the indicator tube socket and components but since I didn't know the tube-to-tube variation in shadow alignment, I finally decided to secure the tube base in a u-clamp so that I could manually align the shadow. If a transformer is used that has a 12.6 VAC secondary (or 5 VAC + 6.3 VAC), a 1629 eye tube can be used. The 1629 has the same specs as the 6E5 but has an octal base and a 12.6 VAC filament.

\* The power switch and key jack were mounted on the rear panel. I decided to use a 3-conductor recessed power receptacle for the 115 VAC line instead of the "traditional" line-cord/grommet combo. The exposed connections on the receptacle, power switch, and 3AG fuse holder were covered with heat-shrink tubing.

\* The front and rear panel lettering was done using a Brother P-touch. This is the 2nd project I have labeled this way. I have no idea how durable this labeling system is for amateur equipment but it's quicker than dry-transfers and looks much better than the old dymo tape labels.

The total time for construction was approximately 22 hours. The total cost was \$75. Even with access to the TRW swapmeet, the cost of the Ten Tec enclosure almost doubled the cost of my xmtr. Even so, I really enjoyed building this xmtr. It went together much "cleaner" using the Ten Tec enclosure and I am looking forward to building other projects with these enclosures.

I only had one problem with this xmtr - 40M crystals were too "chirpy". I decreased the chirp by replacing the 6AG7 but it was still too bad to use on the air. The original circuit used a 22pf/220pf divider in the 6AG7's grid and reducing the value of the 22pf helped. I finally just replaced the 22pf with a 2-25pf PCB mount variable and tuned it for minimum chirp. End of problem. It appears that the 22pf needs to be closer to 13pf.

This xmtr is a lot of fun to use. It brings back a lot of what I "miss" about amateur radio. The feeling of making my first contact with a homebrew xmtr is just as exhilarating now as it was 30 years ago! With (only) 3 watts of output power, I got my share of 569 and 579 signal reports and a few 599 reports.

Crystal control, however, is NOT what it used to be - you used to tune "several" KHz around your crystal (calling frequency) - but not anymore! I finally took Dave Mills/AJ70's advice and started calling CQ more and my "hit rate" went up. Even so, QRP/xtal control takes a bit of patience - you can't be in a hurry!

This article was written 2/93 and originally appeared in Electric Radio, Dec.'93, issue #56, "Building a Two-Tube 6AG7 80/40M CW Transmitter", pgs. 24-27.

# Selected References:

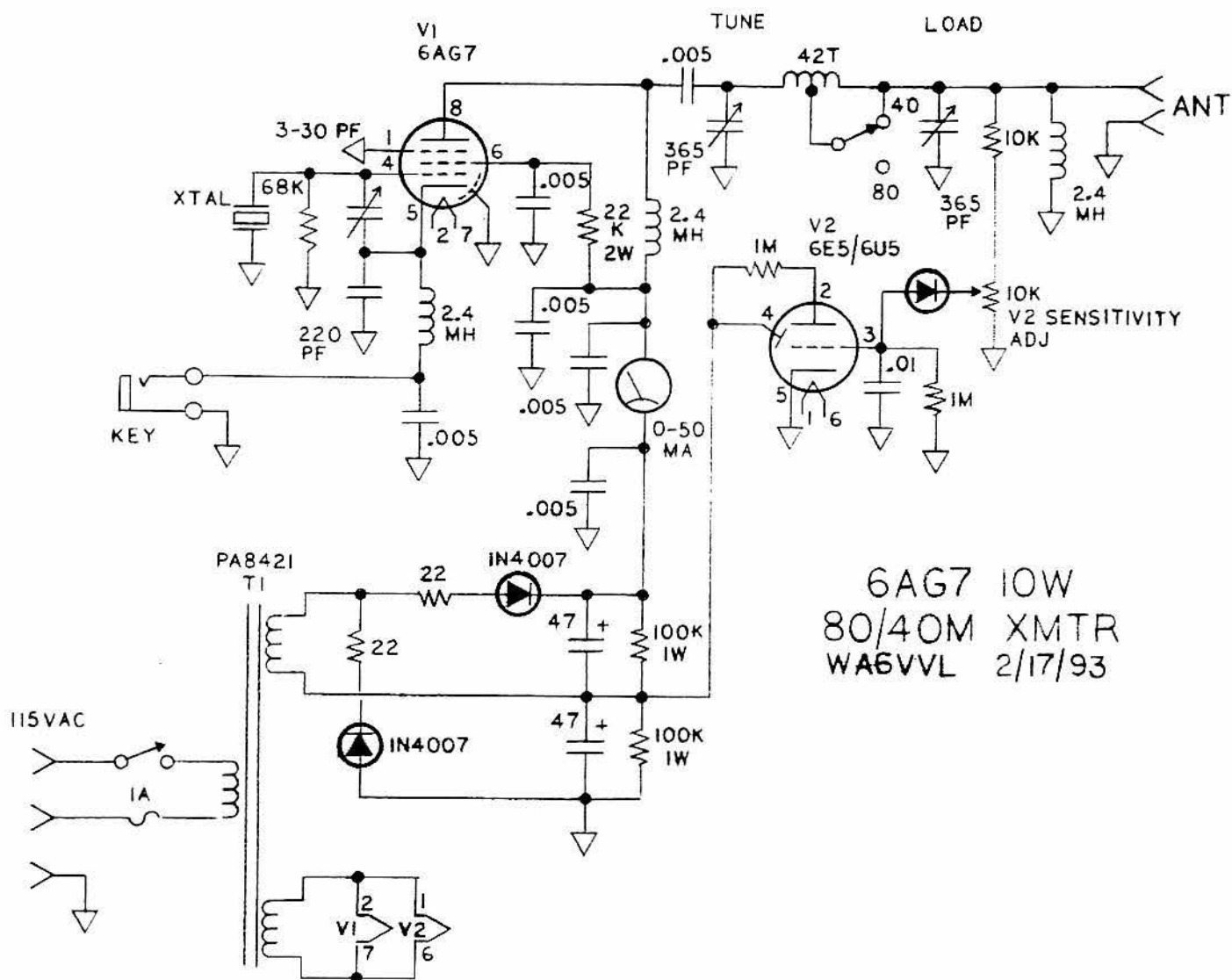
1. RCA 6E5 Electron Ray Tube Data Sheet, Dec. 15, 1944.
2. Encyclopedia on Cathode-Ray Oscilloscopes and Their Uses, John F. Rider and Seymour D. Uslan, 1950.
3. "Crystal-Controlled Oscillators", C.Vernon Chambers, W1JEQ, QST, Mar.'50, pgs. 28-33.
4. "The Novice One-Tube, parts I and II", Donald Mix, W1TS, QST, May '51, pgs. 18-21, 116 and June '51, pgs. 32-35.
5. RCA 6AG7 Power Pentode Tube Data Sheet, Nov. 1, 1952.
6. "Novice 80- and 40-Meter One-Tube Rig", Lewis G. McCoy, W1ICP, QST, Nov.'53, pgs. 28-30, 116.
7. RCA 6U5 Electron Ray Tube Data Sheet, Aug. 9, 1954.
8. "The Glass Eye", Donald L. Stoner, W6TNS, CQ Magazine, Nov.'57, pgs. 66-68, 179.

## - - 2-Tube 6AG7/6E5 80/40M QRP CW Transmitter Parts List - -

Ref	Description	Qty
	PCB, 2-1/4" x 4-1/2", 6AG7 Oscillator	1
	PCB, 2-7/16" x 5", Power Supply	1
L1	PCB, 2" x 3", Coil Mounting	1
C1,2	Capacitor, Aluminum Electrolytic, 47uF 350WVDC, Axial Nichicon TVX2V470MCA, Mallory TCG500T350N1G or equiv	2
C3	Capacitor, Variable, PCB Mount, 2-25pF Mouser P/N 530-189-0509-5, EF Johnson 189-0509-005	1
C4	Capacitor, Silver Mica, 220pF ±5% 500V	1
C5-10	Capacitor, Disc Ceramic, .005uF 1KV	6
C11	Capacitor, Mylar, .01uF 100V	1
C12,13	Capacitor, Variable, 365pF Antique Electronic Supply P/N CV-235	2
CR1,2	Diode, Rectifier, 1000V 1A 1N4007	2
CR3	Diode, Signal 1N4148	1
F1	Fuse Holder, 3AG, Panel-Mount Littelfuse P/N 345613	1
F1	Fuse, Slo-Blo, 3AG, 1A	1
J1,2	Header, 4-pin PCB mount, 0.156" ctrs. Mouser P/N 155-9104, Molex P/N 09-74-1041-P	2
J1,2	Connector, 4-pin Mouser P/N 155-8104, Molex P/N 09-50-3041-P	2
J1,2	Terminal, Crimp, 22-26 AWG Mouser P/N 155-5001, Molex P/N 08-50-0108	4
J3	Socket, Phenolic, FT-243 crystal	1
J4	Connector, UHF, Panel Mount SO-239	1
J5	Jack, 1/4" Phone	1

L1	Coil, 42 Turns, 32TPI 1" dia. 24AWG, tapped @ 21 turns (40M), B&W 3016 miniductor	1
M1	Meter, Panel, 0-50 mA < 2-1/2" sqr. to fit on Ten Tec BU929 front panel Phaotron Model 611 or equiv	1
R1,2	Resistor, Carbon, 22 $\Omega$ $\pm$ 10% 1W	2
R3,4	Resistor, Carbon, 100K $\pm$ 5% 1W	2
R5	Resistor, Carbon, 68K $\pm$ 5% 1/2W	1
R6	Resistor, Carbon, 22K $\pm$ 5% 2W	1
R7	Resistor, Carbon, 10K $\pm$ 5% 1/2W	1
R8	Resistor, Miniature Potentiometer, 10K linear taper 0.2W, Mouser 31JN401 (dia.16 mm) or equiv	1
R9,10	Resistor, Carbon, 1M $\pm$ 5% 1/2W	2
RFC1-3	Choke, RFC, 2.4 or 2.5 mH Mouser P/N 434-1250, Miller P/N 4666	3
SW1	Switch, Toggle, SPST, AC Power	1
SW2	Switch, Slide, SPST, 80/40M Bandswitch	1
T1	Transformer, Power, 115VAC primary, 125VAC @ 0.05A & 6.3VAC @ 2A secondaries Stancor PA-8421, Thordarson 26R38, or Triad R-30X	1
V1	Tube, 6AG7 Power Pentode	1
V2	Tube, 6E5 or 6U5 Electron Ray	1
	Terminal Strip, Lug-Type NTT/Smith P/N 863	1
V1	Socket, Tube, Octal	1
V2	Socket, Tube, 6-pin	1
C12,13	Knob, 1-1/2" dia	2
	Receptacle, Recessed, 115VAC power	1
	Enclosure, 2-1/2" x 9" x 9" Ten Tec P/N BU929 (CONSTRUCTO SERIES)	1
	Panel, Internal, 2-1/4" x 9" Fabricated from BU929 adjustable chassis	1
J4	Screw, 4-40 x 1/4"	4
	Screw, 4-40 x 1/2"	9
	Screw, 6-32 x 1/4"	30
	Screw, 6-32 x 3/8"	8
T1	Screw, 8-32 x 1/2"	2
	Washer, Lockwasher, Internal Tooth, 4-40	12
	Washer, Lockwasher, Internal Tooth, 6-32	26
T1	Washer, Lockwasher, Internal Tooth, 8-32	2
T1	Washer, Flat, 8-32	2
J3	Nut, Hex, 4-40 small-pattern	1
	Nut, Hex, 4-40	12
	Nut, Hex, 6-32	2
	Nut, Hex, 8-32	2
SW2,L1	Spacer, Hex, Aluminum, 6-32 x 1-1/2"	2
	Spacer, Round, Aluminum, 6-32 x 3/8"	8

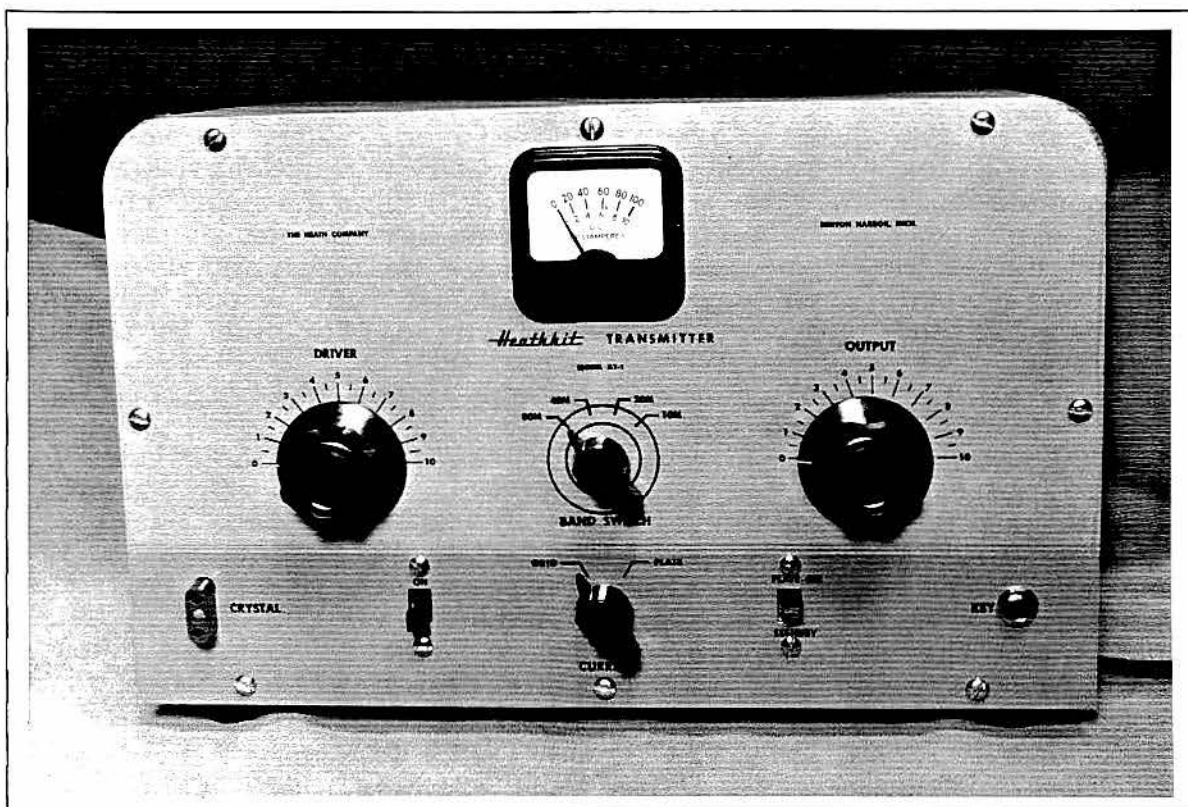
RFC3	Terminal, Insulated, Molded, 6-32	2
	USECO P/N 1613A or equiv	
	Bracket, Right Angle, 6-32	4
V2	U-clamp	1
V2	Screw, 8-32 x 1/2"	1
V2	Washer, Flat, 8-32 (U-clamp spacers)	6
	Grommet, Rubber, 3/8"	2



- - - REBUILDING THE HEATH AT-1 - - -

During my Novice career in 1960 (WV6LXW), there were lots of DX-20s, DX-35s, DX-40s, and a few DX-100s, but I don't recall seeing one AT-1. I used Alan Burgstahler/WA6AWD's DX-20 for many of my Novice and Conditional QSOs. As a result, I have never looked at the AT-1 with much affection. Maybe a curious passing glance if I saw one at the local amateur swapmeets, but nothing more.

After I built my first 6AG7/6L6 xmtr (ER#43) and later a 6AG7/6E5 QRP xmtr, I started looking at the AT-1s a bit differently. I even started advertising for one. Chuck Penson/WA7ZZE's article "The AT-1: Heath Gets on the Air" (ER#46) was the final straw - I now had to have an AT-1!



Front view of the rebuilt Heath AT-1.

The problem at this point was so did everyone else on the planet!! The article "The Lure of Classic Radio" by Marty Drift/WB2FOU and Jim Musgrove/K5BZH in the March '93 QST helped to increase the price of AT-1s by saying in part: "Many Novice transmitters are prized possessions. The Heath AT-1 may sell for well over \$100." Ouch!! Pictures of Marty Drift's restored AT-1 just made my "AT-1 fever" worse. I answered Bob/KA0RRX's AT-1 ad in the March '93 QST by mail (there was no phone number) and mine was the 27th inquiry on his AT-1! I traded Mort/W6KLG for two AT-1 parts units. Both had sheet metal mods to the front panels and chassis



and were missing the power transformers and meters but neither would do for a rebuild. I finally located an original AT-1 from John/KA0DEZ. John's AT-1 was in original condition and had no sheet metal mods - it was a perfect candidate for rebuilding.

My goal in rebuilding the AT-1 was NOT a museum level restoration. I wanted a near-mint working example of an AT-1 and I took a few "liberties" getting there. Readers familiar with the AT-1's wiring can easily spot the under-chassis differences. I don't like using the word "restoration" because of these differences and the methods that I used in rebuilding my AT-1. The following are highlights of my AT-1 rebuild:

- \* The chassis and front panel were completely stripped. The octal sockets, coils, DRIVER/OUTPUT tuning caps, BAND/CURRENT switches, terminal strips, and many components were unsoldered and cleaned.

- \* The front panel was cleaned in a mild solution of soap and water and then polished with a couple of coats of Meguiar's Car Cleaner/Wax. I was pleasantly surprised how well the front panel cleaned up.

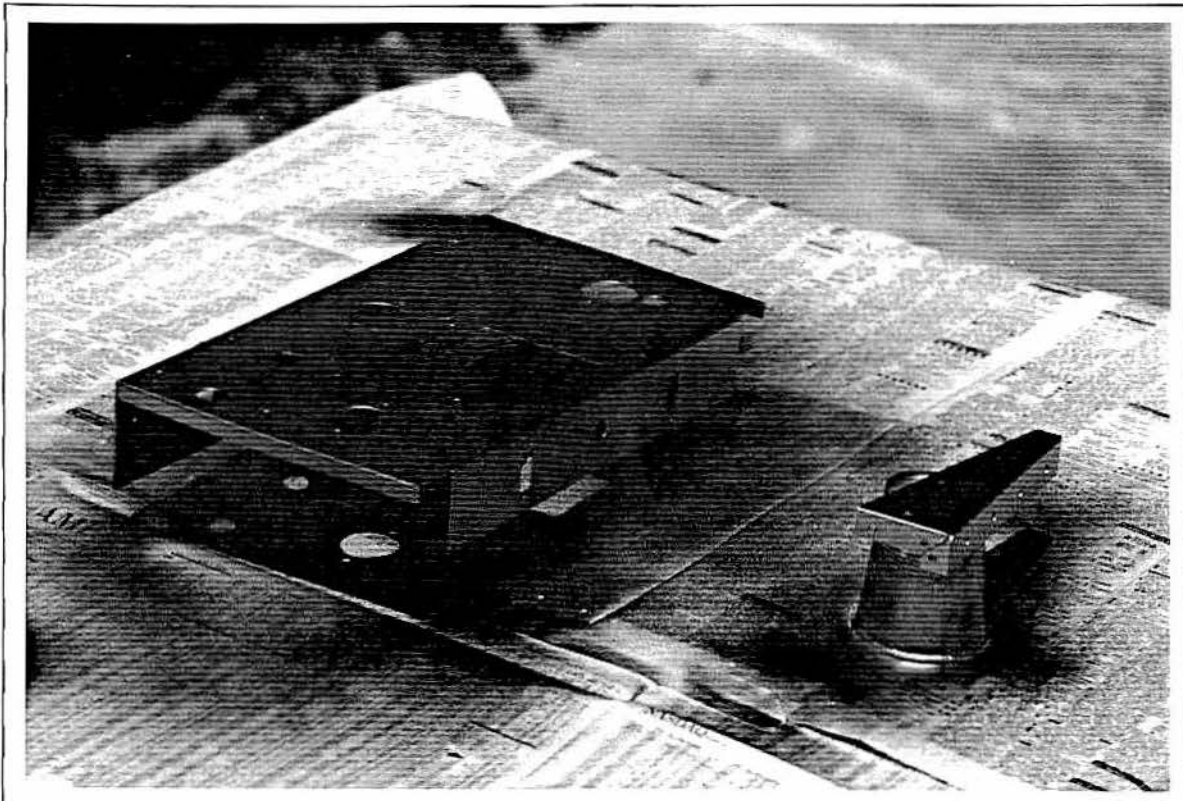
- \* The top of the copper plated chassis was badly corroded while the bottom was OK. The chassis top and coil support bracket were wire brushed with a fine wire wheel. I then painted the top of the chassis and coil support bracket w/Rust-Oleum #7714 copper. This is the first copper chassis I have painted and I am happy with the results. The painted copper is just a tad "brighter" than the original but you can't tell the difference in the color pictures.

- \* The meter was badly rusted and the glass was stained on the inside. I disassembled the meter by carefully folding back the eight tabs on the rear. The bezel was then bead blasted and painted black. The meter glass and meter scale was cleaned and the meter put back together. I folded the eight tabs back using a large flat bladed screwdriver. The meter came out very well but boy do I HATE the way these meters work - I had almost forgotten how bad they are until I tuned up the AT-1. The DX-20/DX-35 has the same type of meter.

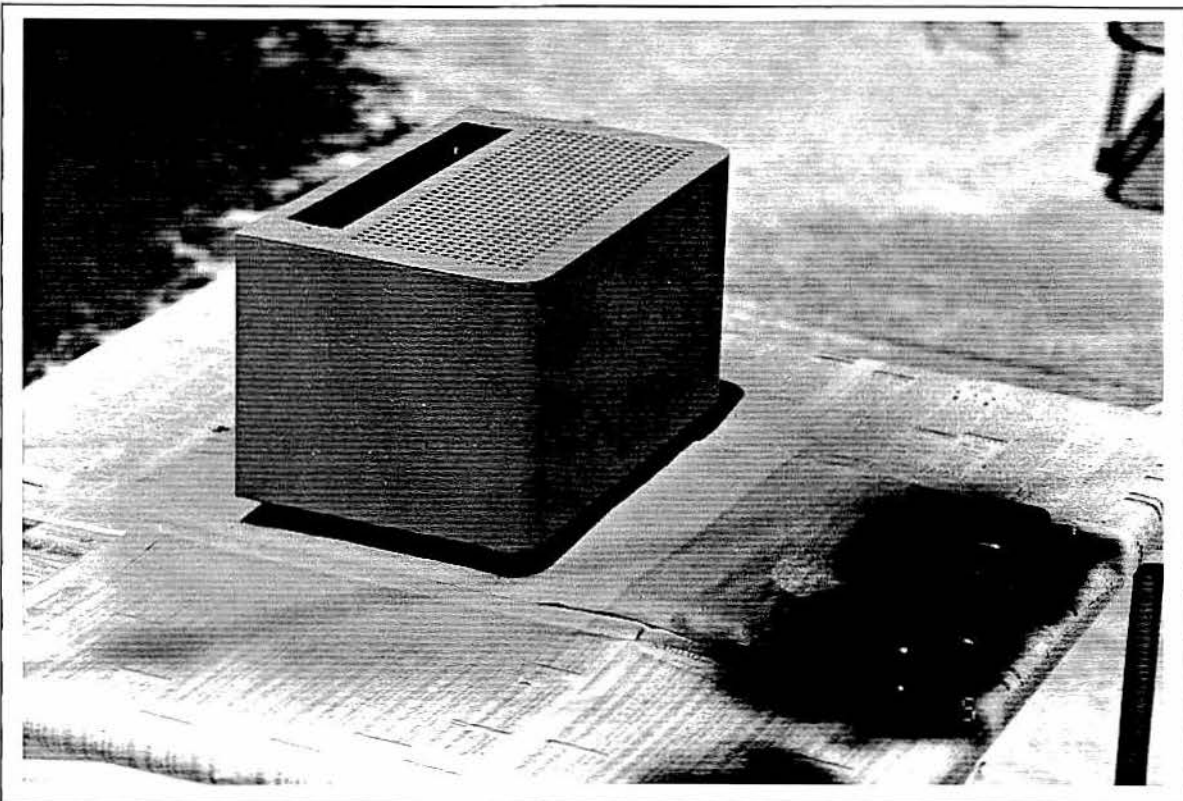
- \* The transformer was run on the bench with the 6L6G/5U4G filaments connected, HV winding open, for several hours before I cleaned it up. The tube filaments represent a 21W load. In my experience, Heath power transformers have NOT been very reliable and I spend a few hours on the bench checking them out before putting them back into a rebuilt unit. The power transformer was then partially disassembled. The endbells were bead blasted and painted black. The xfmr leads were "too short" so I rewired them using vinyl wire.

- \* I replaced the 5U4GB and 6L6GB with the correct "period" tubes, the 6L6G and 5U4G. The AT-1 "looks" a lot better with the "right" tubes in it. All tubes were tested.

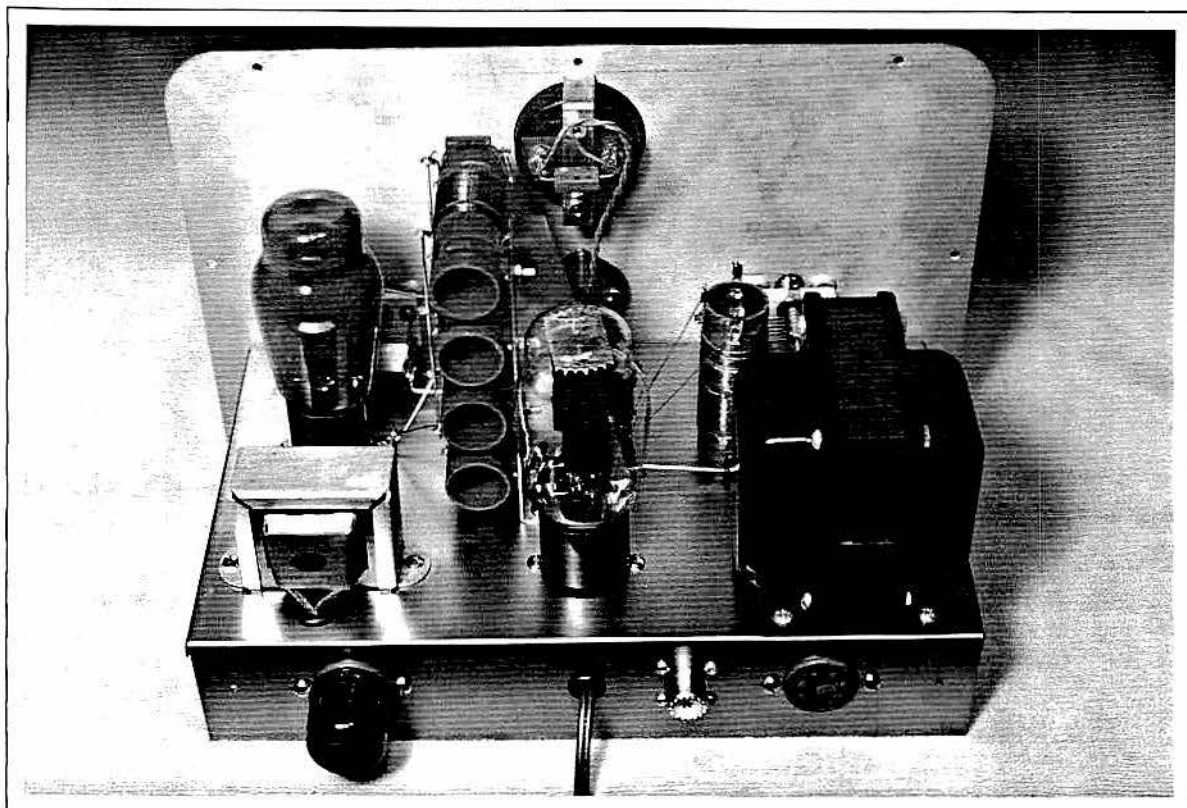
- \* I did not have an original assembly manual to rebuild the AT-1 with so I used the original AT-1s to make some wiring diagrams and rewired accordingly. I also "blew-up" the underside chassis view from Chuck Penson's ER article as a wiring guide - it worked quite well.



The chassis and coil support bracket painted w/Rust-Oleum #7714 copper. The cabinet and xfmr end bells were painted at the same time.



- \* New binder head 6-32 hardware was used to assemble the AT-1. The original used round head.
- \* The cabinet was painted gray wrinkle. It's not a good match to the Heath gray but it's close enough.



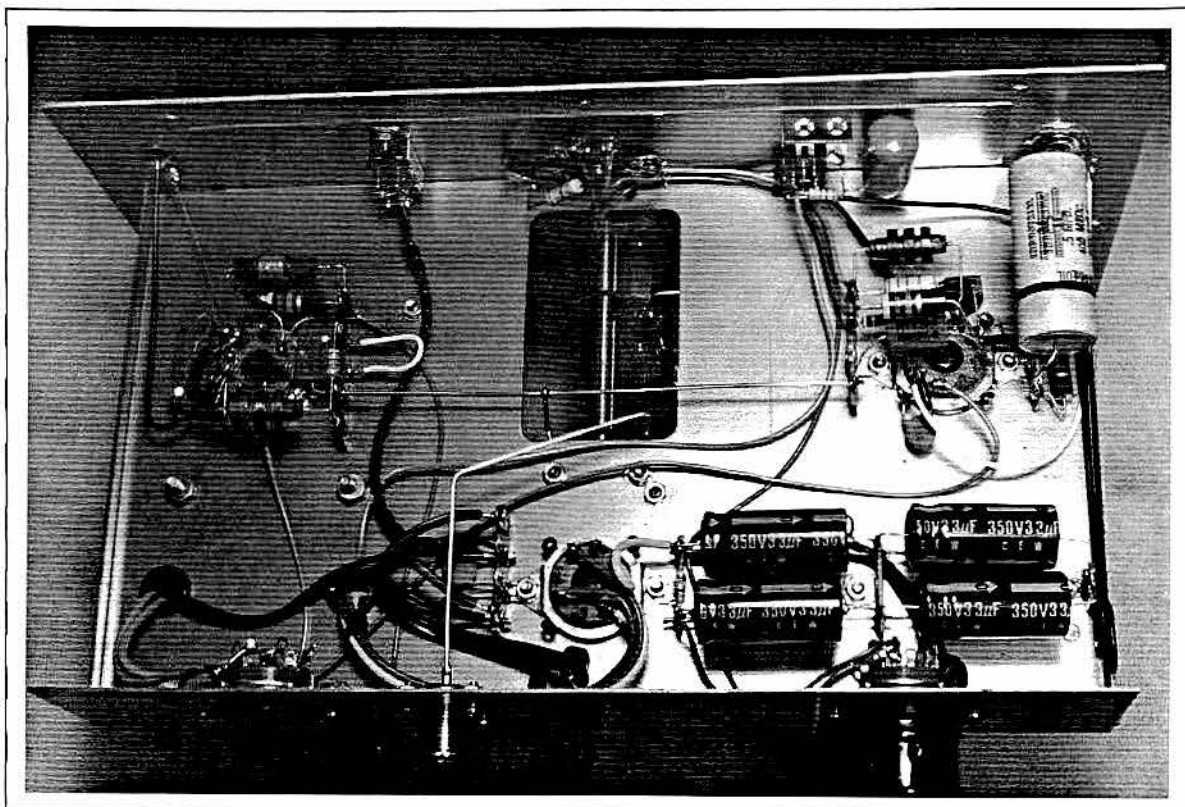
Rear view of the rebuilt AT-1. The chassis has been painted w/Rust-Oleum #7714 copper. The power xfmr was stripped and repainted.

The following are some of the "liberties" I took in rewiring the AT-1:

- \* 33uF 350VDC electrolytics instead of the original 8uF 350VDC.
- \* Two 47K 2W equalizing resistors were added across the 33uF input caps. The original used none.
- \* The new electrolytics are much smaller than the originals so a terminal strip was added next to the 5U4G socket so that the "spare" 5U4G socket pins don't serve as terminals. I did the same thing with the 6L6G socket and the key click filter components.
- \* I added the DX-20 RC network to the STDBY switch to protect the switch contacts. These relatively cheap slide switches are not very reliable, but the RC network helps.
- \* The ground lug for the 33uF filter caps is used as the common ground return for the HV center tap, accessory socket, and key jack.
- \* The meter was bench tested and the 51 ohm current shunt resistor was changed to 43 ohm so that the 100 ma full scale was accurate.
- \* The 6AG7 oscillator stage was changed to cathode keyed.



\* Possibly the worst "liberty" I took was the use of a Radio Shack replacement AC power cord!



Under chassis view.

After 22 hours, it was time for the "smoke" test. Following good Heath practice, I made a few resistance checks before turning on the power. In addition, I learned a long time ago to use a variac and voltmeter to minimize smoke in the shack while bringing up the primary power. After checking filament voltages and the HV winding, I switched from STANDBY to PLATE-ON. I heard the 6AG7 start up on the crystal frequency in the monitor receiver. Closing the key, I peaked the DRIVER for maximum 6L6G grid drive and adjusted the OUTPUT for a dip in 6L6G plate current. The output into a 50 ohm load was 0.5W! Whooops!! I like QRP but this was ridiculous. The problem was an open 90uH 6AG7 plate choke. After replacing it from one of the parts units, the output power into a 50 ohm load was now 8-10W on 80/40M.

When I use xmtrs in the AT-1/DX-20 power class, I use the rcvr to monitor my signal and serve as a sidetone. The original AT-1 6AG7 oscillator is not keyed - it runs all the time - only the 6L6 stage is cathode keyed. I really got tired of the 6AG7 oscillator running all of the time so I changed it to cathode keyed. However, some of my 40M crystals were now too "chirpy". The original circuit uses a 15pf/100pf divider in the 6AG7's grid. I replaced the 15pf with a 5-25pf trim cap and tuned it for minimum chirp. Dave "the ear" Mills, AJ70, 7 miles from my QTH, gave me

good tone reports on both 80/40M and said that there was no evidence of chirp. The same was true for other 40M QSOs.

Using the AT-1 on 80M is a delight - depress the key and adjust OUTPUT for maximum output on a Heath AM-2 relative power meter. Above 80M, the DRIVER must be peaked. If you use the AT-1's PLATE meter to dip the 6L6G, adjust the OUTPUT for dip and then set the meter switch to mid-position/straight-up. The meter banging from stop-to-stop during QSOs will drive you "crazy" if you don't! I'm always afraid that the meter is going to "beat itself to death"/"self-destruct"!

This xmtr is now my favorite among the AT-1, DX-20, and DX-40. Quite a change in attitude in (only) six months. I like the AT-1's mechanical design and electrically, it is a classic 6AG7/6L6 xmtr. Chuck Penson's enthusiasm for the AT-1 is well founded and his article is responsible for at least one AT-1 "convert" - thanks Chuck.

This article was written 5/93 and originally appeared in Electric Radio, June '93, issue #50, "Rebuilding the Heath AT-1", pgs. 24-27.

#### Selected References:

1. "Two-Tube All-Band Transmitter", Radio Handbook, 13th Edition, pgs. 476-480.
2. "Hints and Kinks for the Experimenter - Operating the Heathkit Models VF-1 and AT-1 at 21 Mc.", E.B. Mullings, W4MKZ/8, QST, Apr.'55, pg. 50.
3. "More Power with the AT-1", Lewis G. McCoy, W1ICP, QST, Oct. '55, pgs. 36-39, 140.
4. "Economy Modulator for the Heathkit AT-1", John Gallamore, W0UJM, QST, Nov.'56, pgs. 36-37.
5. "Antenna-Changeover Relay for the AT-1", Ralph Schachat, W1GIF, and Martin Glicksman, CQ Magazine, Mar.'57, pgs. 37, 118.
6. "Restoring the Heath AT-1", Marty Drift, Radio Age, Feb.'93, Vol. 18, No.2, pg. 8.
7. "The AT-1: Heath Gets on the Air", Chuck Penson, WA7ZZE, Electric Radio, Feb.'93, issue #46, pgs. 20-23, 33.
8. "The Lure of Classic Radio", Marty Drift, WB2FOU, and Jim Musgrove, K5BZH, QST, Mar.'93, pgs. 39-42.



- - - WHAT YOU ALWAYS WANTED TO KNOW ABOUT THE 6AG7/6L6 - - -  
 - - - BUT WERE AFRAID TO ASK - - -

I have built and/or breadboarded several 6AG7/6L6 80/40M transmitters during the last year and have not been particularly pleased with their output power. Even though I was very happy with my rebuilt Heath AT-1 (ER#50), its output power was still relatively low - 8-10W - not much better than the 5W output from my single tube 6AG7 80/40M QRP rig that uses a much smaller power supply and is one third its size.

One of the spare AT-1 "parts unit" left over from the AT-1 rebuild had a missing power transformer so I finished stripping the power supply components off the chassis and made a 6AG7/6L6 test bed out of it. I connected this stripped AT-1 to a Heath IP-17 power supply so I could easily vary the 6AG7/6L6 plate voltages as I ran the various tests. A second Heath IP-32 power supply was used for dual-voltage tests.

One of the most popular configurations of the 6AG7/6L6 is using the 6AG7 as a crystal oscillator with an untuned (RFC) plate. The AT-1 uses this configuration on the 80M band. Heath was apparently concerned about parasitic oscillations and the lack of neutralization when running the 6L6 "straight-through" on 80M so they left the 6AG7 plate/6L6 grid untuned. The 6L6 is operated as a doubler on 40-10M, so traditional LC tuning is used instead of the 90uH RFC. Measuring the 6L6 grid drive voltages and output power on the 80M vs 40M band in the AT-1 is a convenient way to evaluate the untuned vs tuned drive configuration.

The following table summarizes the differences in VP-P grid drive voltages in the AT-1. 6AG7 plate voltage = 6L6 plate voltage = VDC. The 80M band uses an untuned 1mH RFC and the 40M band uses a tuned LC network. The DC input power to the 6L6 averaged about 76mA @ 385V or about 30W. The 6L6 dipped to 50mA on both 80/40M but maximum output did not occur at the dip on either band.

VDC	untuned RFC 80M		tuned LC 40M	
	6AG7 VP-P	Power Out W	6AG7 VP-P	Power Out W
385	86	7.5	460	9.0
350	76	6.0	430	7.0
300	63	4.2	345	5.0
250	50	3.0	280	3.2
200	38	1.9	200	2.0
150	27	0.9	150	1.0

Notes:

1. The 6AG7's output was measured at its plate, pin 8, key-down. The voltage at the 6L6's grid is a bit less.
2. The output power was measured with a Kenwood AT-230 on the 20W

range.

3. A 50 ohm dummy load was used.

I tested a number of chokes in the range of 500uH - 2.5mH in the plate of the 6AG7. They all performed about the same. A National R-33 100uH choke increased the drive to the 6L6 about 40% but did not increase the output power (for reasons that will be explained later).

Lewis McCoy/W1ICP pointed out in his January, 1953, QST article "A Novice 35-watter" (1955/56 ARRL handbook) that the 6AG7's plate RFC must be broadly resonant at 5MHz to provide sufficient drive to the 6L6 on 80/40M. He recommended a Millen 34300 100uH RFC. I (mistakenly) assumed that not using this RFC was the reason for the relatively low 5W output from my first 6AG7/6L6 xmtr (ER#43) - it wasn't.

My tests indicate that the drive available from a 6AG7 in an untuned configuration will **NOT** drive the 6L6 into class C operation - it's not even close. The AT-1 operates the 6AG7/6L6 at 400V key-down which maximizes the 6AG7's output - about 86VP-P. At AT-1 plate voltages of 400V and class C operating angles of 120-140°, the required grid drive is 234-308VP-P.

The indicated grid drive on the AT-1 and similarly metered grid circuits does not measure the tube's actual grid current - it measures the relative drive voltage across the grid-leak resistor. The actual current through the grid-leak resistor bears little relationship to the actual grid current. The majority of the current through the grid leak occurs during the negative portion of the grid voltage waveform when no 6L6 grid current flows. Even though class C operating angles are 120-140°, positive grid current occurs during only 43-45° at AT-1 plate voltages of 400V using the 6L6.

If the waveform of the grid voltage is sinusoidal (e.g., from a tuned LC tank), the following formula may be used to calculate the required class C VP-P grid voltage:

$$\text{VP-P grid drive} = \frac{\text{max pos grid voltage} - (\text{grid cutoff voltage})}{1 - \sin((180^\circ - \text{desired operating angle})/2)} \times 2$$

An example using the measurements from the AT-1:

$$\text{VP-P grid drive} = \frac{(12\text{V} - (-65\text{V})) \times 2}{1 - \sin((180^\circ - 120^\circ)/2)} = \frac{77\text{V} \times 2}{1 - \sin(30^\circ)} = 308\text{V}$$

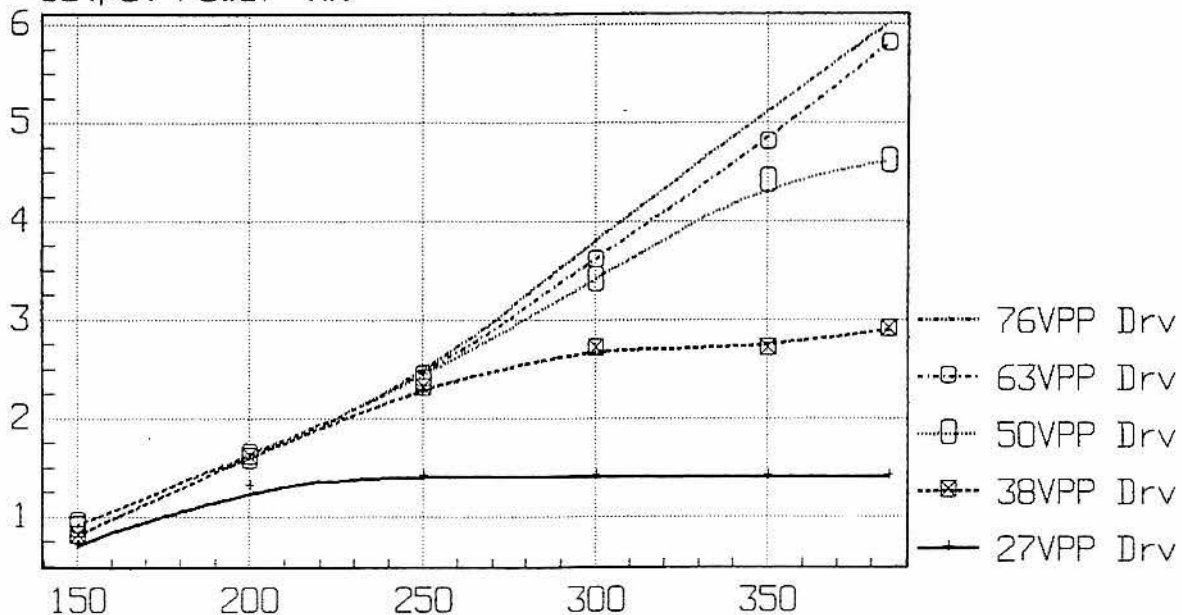
Another very revealing test is output power vs 6AG7 plate voltage (untuned/RFC) vs 6L6 plate voltage using dual power supplies. Varying the 6AG7's plate voltage is a convenient method of varying the drive to the 6L6 as the 6L6's plate voltage is changed.

		6L6 Plate Voltage					
		150V	200V	250V	300V	350V	385V
6AG7	150V (27VPP)	0.7W	1.3W	1.4W	1.4W	1.4W	1.4W
	200V (38VPP)	0.8W	1.6W	2.3W	2.7W	2.7W	2.9W
	250V (50VPP)	0.9W	1.6W	2.4W	3.4W	4.4W	4.6W
	300V (63VPP)	0.9W	1.6W	2.4W	3.6W	4.8W	5.8W
	350V (76VPP)	0.9W	1.6W	2.4W	3.8W	5.1W	6.0W

Notes:

1. Because the output changes were relatively small, the output voltage was measured and output power calculated.

6L6 OUTPUT POWER  
VS 6AG7 DRIVE VS 6L6 PLATE VOLTAGE  
Output Power (W)



6L6 Plate Voltage  
6L601.GIA DWIsh 23Jun93

Referring to the table or graph 6L601 above, a few conclusions can be drawn:

\* In designs where the 6AG7 and 6L6 are run from different plate voltages, the grid drive can be way too low. In fact, with 6AG7 plate voltages <300V and 6L6 plate voltages >350V, the 6L6 will not even be driven into cutoff, let alone class C!!!

\* There is a minimum level of grid drive required to obtain maximum output from the 6L6 at a given level of 6L6 plate voltage. That minimum level will NOT drive the 6L6 class C and is approximately:

VP-P grid drive = positive grid voltage - (grid cutoff voltage)

\* A good "rule of thumb" when using a 6AG7 with an untuned/RFC plate to drive a 6L6 is to use the same plate voltage for both tubes. In this respect, the AT-1 "got it right".

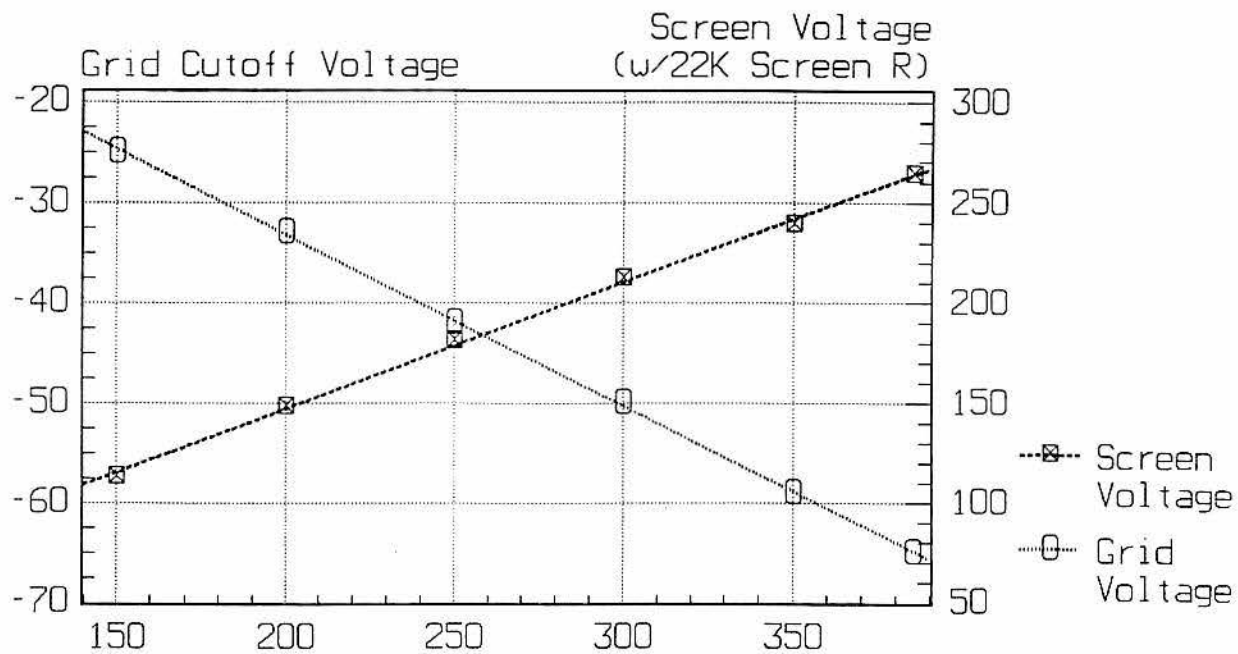
I tested the 6L6's grid cutoff and screen voltage as a function of its plate VDC:

Plate VDC	Grid Cutoff Voltage	Screen Voltage
385	-65	264
350	-59	239
300	-50	212
250	-42	181
200	-33	148
150	-25	113

Notes:

1. I defined cutoff when the 6L6's plate current measured 1 mA.
2. The 6L6 screen resistor was a 22K connected to the 6L6's plate VDC.

6L6 GRID CUTOFF & SCREEN VOLTAGE  
VS PLATE VOLTAGE



6L6 Plate Voltage  
6L602.GIA DWIsh 23Jun93

At this point, I was starting to get the feeling that the 6L6 left a lot to be desired in the RF amplifier department. Heath's 2nd generation AT-1, the DX-20, uses a 6DQ6A in the final. With the exception of the 6DQ6's plate cap, the basing is the same as the 6L6. I substituted a 6DQ6B for the 6L6 in the AT-1 test bed and connected its plate using the DX-20's parasitic choke to pin 3 of the octal socket. The output power on 40M was now 16W!! The plate current was also way up, about 130mA. What a difference!! There was also a 15% increase in the grid drive available using the 6DQ6B.

Swapping tubes sure put the 6L6's performance in perspective but I'm not sure that the AT-1's power xfmr can safely handle the 6DQ6B's additional plate current. The 6DQ6B can be added by solid- stating the 5U4G and removing its 15W filament load from the xfmr's secondary. A solid-state 5U4G equivalent can be built into an octal tube base so that the AT-1 can be quickly changed back to its original configuration. Don't forget to parallel the meter shunt if you change to the 6DQ6B.

Bottom line? The "venerable" 6L6 is OK for building that 6AG7/6L6 classic, but it is probably not the best choice if you are interested in maximizing the output power for a given set of components.

Although these tests were done using an AT-1, they are consistent with the results I have obtained from other 6AG7/6L6 designs. With the exception of the AT-1's fixed-link-coupled output, the rest of the design is classic 6AG7/6L6. Output powers using a pi-net will be a slightly higher, but the relationships between plate voltages and grid drive should be similar.

For additional reading, try Lewis McCoy/W1ICP's "More Power with the AT-1, Simple Modifications for Greater Output" in the October, 1955, QST, pgs.36-39, 130. I wouldn't classify the mods as simple but the article covers a lot of ground. W1ICP recommends changing the 6L6 to a 6BQ6.

This article was written 7/93 and originally appeared in Electric Radio, July '93, issue #51, "Notes on the 6AG7/6L6", pgs. 16-17, 32.

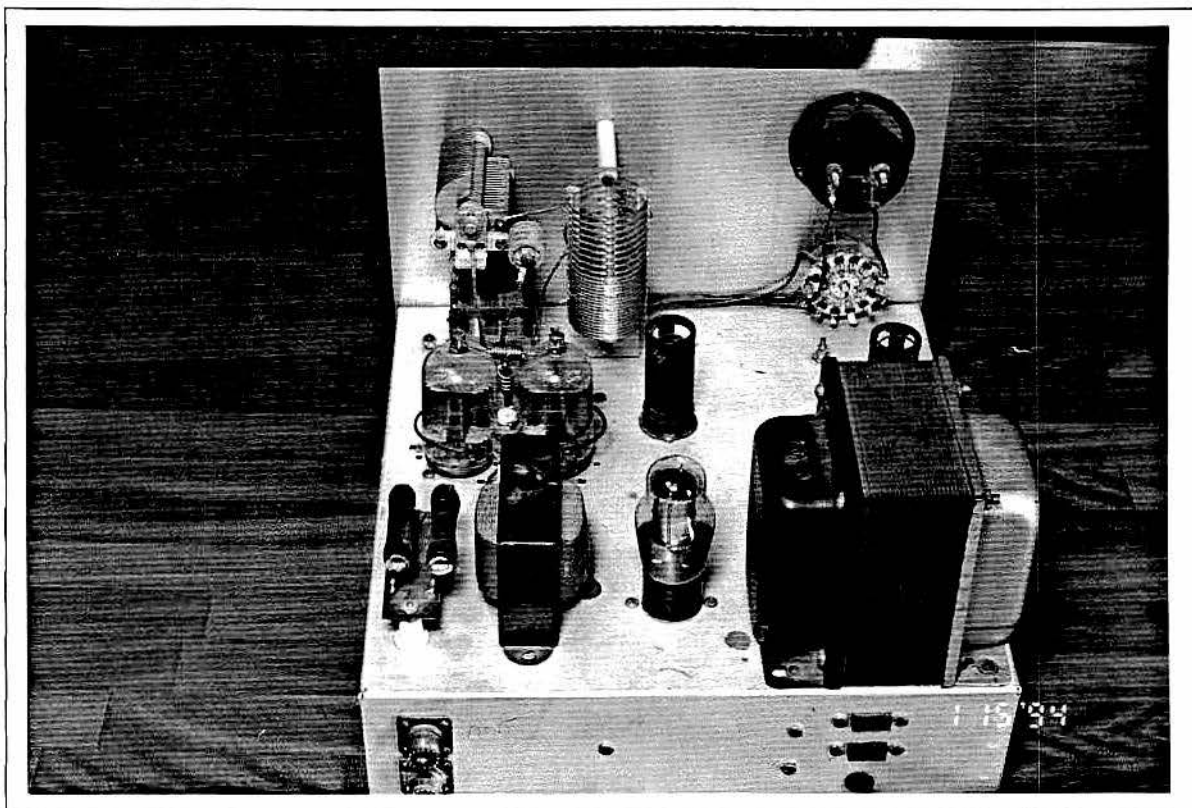
#### Selected References:

1. RCA 6AG7 Power Pentode Tube Data Sheet, Nov. 1, 1952.
2. RCA 6L6 Beam Power Tube Data Sheet, Nov. 5, 1954.
3. RCA 6DQ6-B Beam Power Tube Data Sheet, 3-61.
4. "Crystal Controlled Oscillators", C. Vernon Chambers, W1JEQ, QST, Mar.'50, pgs. 28-33.



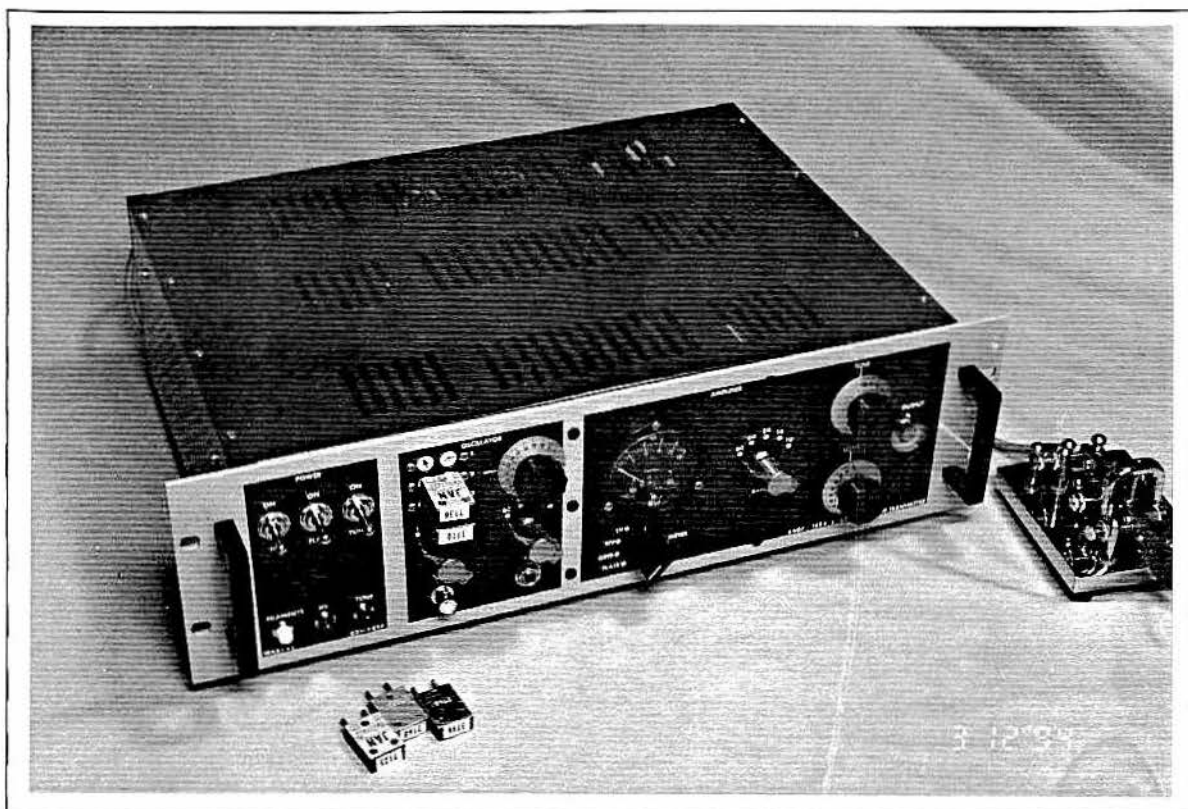
- - - 6AG7/1625 100W 5-BAND CW TRANSMITTER - - -

During a telephone conversation with Barry/ER in November '93, he asked me "if I ever built anything besides 80/40M QRP rigs? Had I ever considered building a bandswitching 100W class transmitter?". I didn't think too much about that conversation until Bob Dennison, W2HBE, sent me a photo of his DENNISON T-807 HF TRANSMITTER in a "post card" (ER#58, pg. 25). Bob sent me some additional pictures of this "beauty" in late December - what a gorgeous job of homebrewing! Soon after, Dave Mills, AJ70, offered me a homebrew self-contained dual-6GJ5 bandswitching CW xmtr for \$20 that he had picked up at the TRW swapmeet a couple of years ago - I bought it as a "parts unit". So with a little push from Barry and a little help from Dave, Bob Dennison was again the inspiration for another project.



Homebrew dual-6GJ5 bandswitching CW xmtr that was the source for many of the major components for the 6AG7/1625 xmtr. This "parts unit" was purchased for \$20 at the local Rio Hondo amateur radio swapmeet.

The transmitter that I decided to build is based on the 100-Watt Transmitter and 150-Watt Amplifier featured in ARRL's First ('63) and Second ('71) Editions of **Understanding Amateur Radio**. Both projects use 1625's, a version of the 807 that has a 12.6 VAC heater and a medium 7-pin base.



Front view of the completed 6AG7/1625 5-Band 100W CW xmtr.

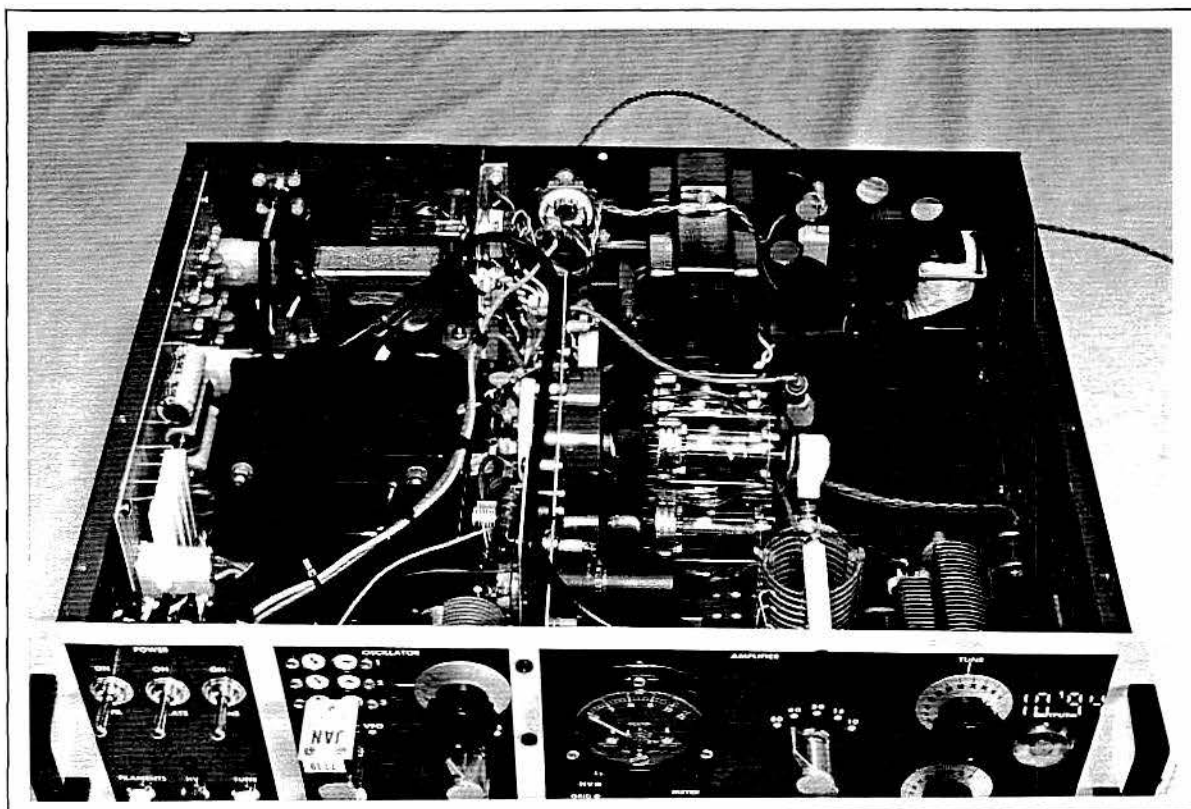
I was "introduced" to the 1625 (VT-136) in the early 60's when I learned about converting command set xmtrs. A pair of 1625's was used in the ATA, SCR-274N, and ARC-5 command transmitters and their associated modulators. Reference Walt Hutchens, KJ4KV, Electric Radio In Uniform column in ER#11 pgs. 4-7, 20-23, and ER#12 pgs. 4-7, 26-29. The 1625 is still relatively "plentiful" at local swapmeets and I have bought several NOS for \$1/each. The 1629 "magic-eye" tube was also used in the command xmtrs, has an octal base, is easier to find and is usually cheaper than its 6E5/6U5 6-pin counterparts.

The following are some of the highlights and comments about the completed transmitter:

- \* The 6AG7 oscillator is identical to and uses the same PCB that was used in my 6AG7/6E5 80/40M xmtr (ER#56). An 80-15M plate tuning network has been added to provide sufficient drive for the 1625 output tubes. The plate tuning network uses B&W miniductor stock, 36T of 3016 and 5T of 3011, and a 100 uuf variable. Centralab PA-6003 2-pole 5-pos non-shorting steatite switches are used for the xtal/vfo and band switches.

- \* The final amplifier uses two 1625's in parallel. An additional 1625 operates as a clamp tube - a bit "overkill" but then 1625's were relatively cheap when the original articles were written (3/\$1 in '60 from "TAB"). With no drive from the 6AG7 stage, the clamp tube reduces the 1625 amplifier screen voltage to a value that prevents excessive plate current during key-up

conditions. The 1625 cathodes are grounded - they are not keyed with the oscillator stage. This technique is successfully used in the Johnson Viking Challenger, a 120W CW, 70W AM transmitter. I set up my Eico Model 666 Dynamic Conductance Tube Tester and tested 24 1625's and selected a matched pair for the amplifier. I then bench tested the remaining tubes and selected the 1625 that gave me the lowest screen voltage when used as a clamp tube - there was almost a 3:1 difference between the tubes - so the test was worthwhile. Tubes other than the 1625 can be used for the clamp tube - the Viking Challenger uses a 6AQ5. With a plate voltage of 620 VDC, the 1625's resting plate current is 80 mA with a clamped screen voltage of 65 VDC so the clamp tube's plate is only dissipating about 2 to 2-1/2 watts, depending upon the value of the screen resistor.



Top front view. The pwr xfmr is "sandwiched" between the pwr supply PCB and the RF deck. The Howard Industries shaded-pole fan is at the right-rear corner of the enclosure.

\* While it's not usually necessary to neutralize a 1625 amplifier (and this amplifier is no exception), just in case, I insulated the shaft of the 6AG7's 100 uufd plate tuning capacitor using a fiber shoulder and flat washer and then grounded the rotor. The rotor can be easily ungrounded and the neutralization components added if it proves necessary.

\* The maximum power dissipation of the 1625's screen resistor occurs during clamp, when almost the full plate voltage is across it. Keep this in mind when selecting the screen resistor.

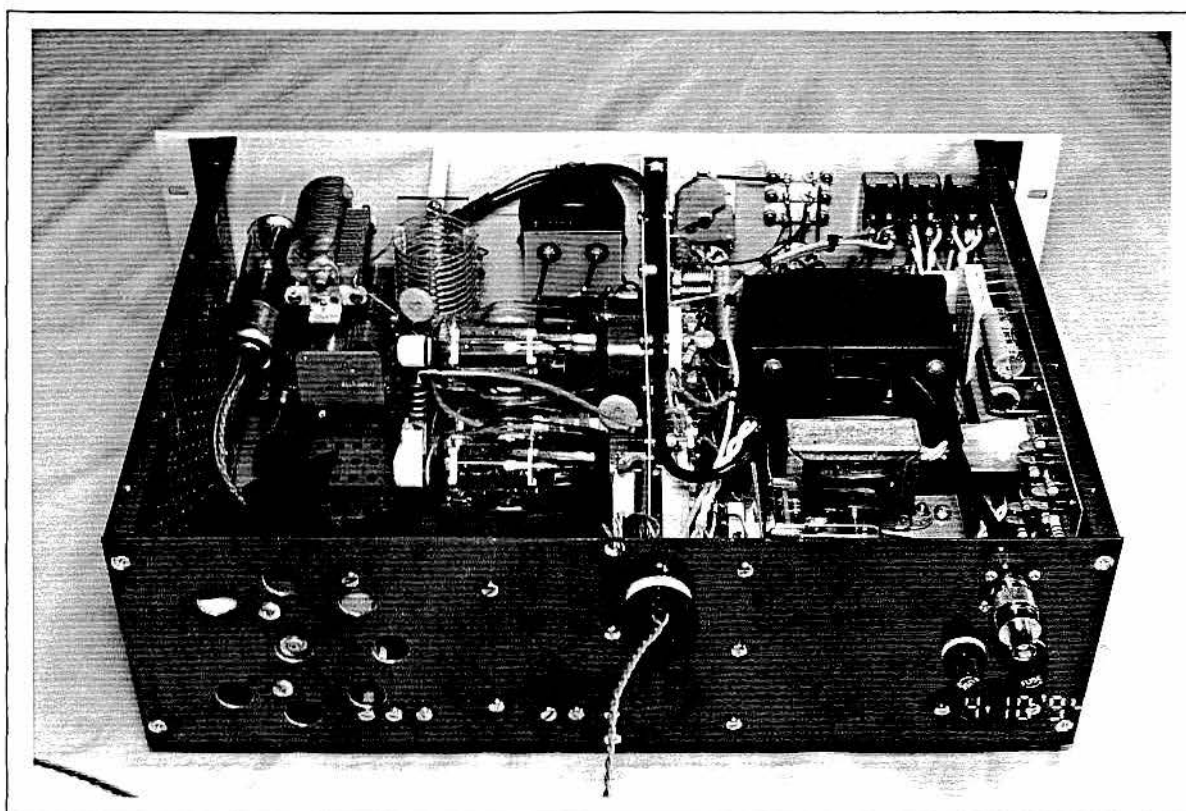


According to the original article, the screen voltage should be about 300VDC, when the output is fully loaded. If the HV is about 600V, use a 15K 25W screen resistor. Increase it to 20K 35W if the HV is 700VDC or more.

\* The 1625's pi-network coil assembly is an 18.6 uH Illumitronic Engineering Vari-Pitch PI Air-Dux P/N 1212D6 that covers 80-10M. The plate tuning capacitor is a Bud MC-1860 300 uufd variable and the loading capacitor is a three-section "broadcast variable" with approximately 1100 uufd total capacitance. The bandswitch is a large 1-pole 5-pos non-shorting ceramic switch. All of these parts came from the "parts unit".

\* The amplifier operates "straight-through" on all bands except 10, where it doubles.

\* The 1625's plate choke is a National R-300S 1 mH 400 mA from the "parts unit". The E.F. Johnson 0-100 and National HRB die-cast knobs also came from the "parts unit".



Top rear view. The 1625 clamp tube is closest to the 12.6VAC filament xfmr.

\* The 1625's use National ceramic XC-7L 7-pin tube sockets and SPP-3 ceramic plate caps. National CS-6 ceramic xtal sockets are used in the oscillator. Use fiber or nylon washers to mount the 7-pin ceramic sockets and don't over-torque the mounting hardware as the socket can be easily cracked. Towards the end of this project, I needed to find a replacement 1625 socket. After about a dozen calls and no socket, I came to the conclusion that medium 7-pin 1625 sockets are a bit rare. My advice is to lay your hands

on the sockets before committing your design(s) to 1625's - the 807's 5-pin socket is much easier to find.

\* The 1629 "magic-eye" indicator tube assures that the xmtr is tuned for maximum output. The 1629 takes about -7.5 VDC to close the eye so I used a fixed 120K/10K resistive divider across the RF output. The tube's base is secured in a u-clamp mounted to an L-shaped aluminum bracket mounted against the front panel. The 1629 is rotated in its u-clamp to align the shadow. The L-shaped aluminum bracket was notched to clear the loading cap's plates at minimum capacity. Don't install the 120K/10K RF divider in the 1629's shell - The 1629 doesn't like the full RF voltage appearing near its base.

This xmtr is designed around a TES Industries RB-3U 19" x 12" x 5-1/4" racking enclosure. It's a bit pricey at \$130, but it is a very high-quality enclosure. I "salvaged" it from a piece of test equipment that I built four years ago. The replacement 5-1/4" front panel was also purchased from TES Industries. There are other, significantly cheaper, rack mount enclosures available. SESCO, for example, advertises their model 3RU10 (19" x 10" x 5-1/4") in CQ Magazine for \$46.30. The E3120D (19" x 13" x 5-1/4") enclosure distributed by ALLTRONICS is \$54.95. Whatever enclosure you select, make sure it is "modular" enough to repair and/or modify the xmtr.

The following are highlights and comments about the construction:

\* You will notice that I didn't use a chassis base to build this xmtr. Almost all the parts are mounted to the front and rear panels. An L-shaped aluminum bracket attached to the front panel contains the "RF-deck" and serves as a shield between input and output RF circuitry.

\* The front and rear panels were carefully layed out on a quad-pad. I didn't start the layout until I had all the parts. I used the original quad-pad layouts and taped them to the panels as a center punching guide. I used a sharp scribe as a center punch instead of the automatic type because I can more accurately and consistently locate the holes with the scribe. After center punching, I used a small #60 drill (0.040") as a pilot drill. The next hole size was the 4-40 holes for the meter so I drilled all the holes with this drill also. It took a bit more time to double- and triple-drill the panels but the accuracy is very good using this technique - especially if a drill press is used.

\* Holes up to 3/8" were drilled. Holes from 3/8" to 1/2" were enlarged from 3/8" with a T-handled reamer. I don't like to use drills larger than 3/8" in soft aluminum - even with a drill press!

\* All of the larger 5/8", 1", 1-1/8", 1-1/2", and 2-1/4" holes, were done with Greenlee chassis punches. I used several pieces of paper between the chassis punch and the painted panels with the cutter portion of the punch against the inside/non-painted side. The edges of the punched holes were quite satisfactory cosmetically with minimal "scuffing" of the paint. Just a touch of oil under the punches' drive screw will



make the punching operation easier.

\* The TES enclosure uses countersunk 4-40 screws to assemble it. The paint is very thick and there was no electrical connection between the various pieces so I spot-faced the countersinks to ensure good electrical connection.

\* The location of the RF deck sub-panel was dictated by the front panel's layout. As a result, the power supply components are a bit "tight", one of the reasons for stacking the filter chokes. The only mechanical support for the RF deck is to the front panel. The rear of the RF deck is unsupported.

\* One last comment about the mechanical design. Mechanically, the xmtr will pose no problem in the shack. I suspect, however, that this xmtr could not survive UPS no matter how well it is packed. There are too many relatively heavy components (e.g., 12.6VAC filament xfmr, fan, plate xfmr, ....) mounted on relatively light gauge aluminum. It's really a non-problem unless you intend to ship the finished xmtr.

The finish on the front panel is a bit "different". I have used this technique on both industrial test equipment and amateur equipment for almost thirty years and I kind of like it.

\* After the front panel is drilled, punched, and deburred, the painted surface is **very lightly** wet-sanded with 400 WETORDRY paper.

\* I use the thin 3M brown "packaging tape" for masking. I find that this tape has almost no "bleeding" when the edges are gently rubbed with the plastic tip of a ball point pen - something round but not sharp. Regular masking tape "bleeds" way too much, no matter how well the edges are prepped - I don't recommend using it. If you're not sure how your tape will perform, mask and paint a piece of scrap aluminum.

\* After masking, the panel is painted with several light coats of Krylon, dark blue in this case. Don't let the paint build up at the tape edges. After about fifteen minutes, the masking tape is **very carefully removed**. This tape sticks to **everything**, so be very careful removing it or you will end up with something unexpected sticking to your newly painted panel. I remove the tape when the paint is still tacky so the paint doesn't peel. Even though the surface has been lightly sanded, the Krylon coat may peel after it has dried. Let the front panel dry overnight before applying the dry transfers.

\* The dry transfers are applied using a very soft, somewhat dull, colored pencil. After a successful transfer, place a clean sheet of white paper over the transfer and lightly rub the transferred letter or words through the paper to "set" them. I don't have a preference for a particular brand of dry transfer - everything I have used, works. Just remember to keep the back of the transfers clean, against the supplied protective backing when you are through using it. The transfer sheets will last for years if they are taken care of.

\* The finished front panel is then lightly sprayed with a clear Krylon overspray in several light coats. I try and get a matte finish but consistency is very important. I let the panel set about a week before I start the mechanical assembly.

\* Take it easy during mechanical assembly because the paint will still be relatively soft - especially when you are rotating screw heads against the surface. I use 3/8" and 15/32" flat washers between the panel and nuts on control shafts and toggle switches to keep from marring the front panel during assembly.

I will admit, right up front, that I got a little "carried away" with the AC control circuitry. There were a few things I wanted to experiment with and I thought this was a good platform to use.

\* I used a separate 12.6 VAC CT 3A Radio Shack 273-1511B filament xfmr, T1, for the 6AG7, 1629, and 1625 filaments. The first front panel DPDT switch, SW1 (FIL), applies power to the filament xfmr. The filament xfmr is connected to an Amperite 6NO45 octal-base time-delay relay, K1.

\* The NO contacts of the 6NO45 control the coils of two Potter & Brumfield 120VAC KRP11AN relays, K2 and K3. K2's DPDT contacts are in series with the second front panel DPDT switch, SW2 (PLATE), which applies power to the primary of the plate xfmr, T3. The 6NO45 guarantees that the filaments have a minimum of 45 seconds to warm-up before plate voltage can be applied. K2 and K3's relay coils are connected by a shorting link on the rear panel accessory socket for external T/R switching.

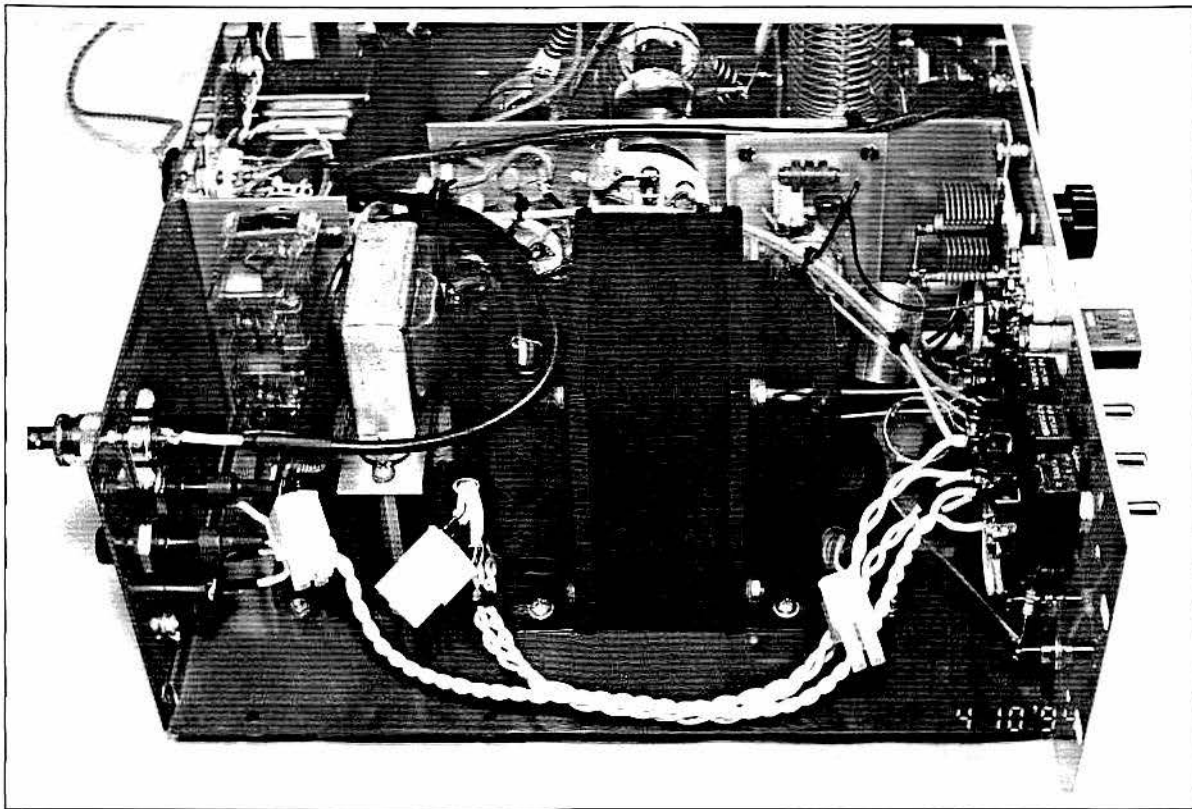
\* SW1 (FIL) also applies 120VAC to a rear panel mounted 4.2" fan through a 250 $\Omega$  15W resistor. When plate voltage is applied to the 1625's, a set of SPDT contacts in K3 short out the 250 $\Omega$  15W resistor, increasing the air-flow to the 1625's during transmit. The fan is a Howard Industries 2-pole shaded pole motor with a 5-blade 4.2" nylon fan. This fan is relatively quiet and delivers about 100 CFM at full speed during transmit. After several days of CW QSOs with the new xmtr, I found out that the "relatively quiet" fan was driving me "nuts", so I am experimenting with different dual speed resistor values. The enclosure top, above the three 1625's, is cool to the touch after several hours of operation, so not much cooling is required.

\* The remaining SPDT contacts in K3 are available at the accessory socket, J1. A separate 6.3VAC 0.6A filament xfmr secondary, T2, is also available at the accessory socket.

\* The front panel incandescent pilot lights use Radio Shack 272-340 holders with 272-1142 6V 100 mA bulbs (E-5 base). I reduced the bulb's current a bit with 22 $\Omega$  1W series resistors - they are too bright without them. An added advantage of the 22 $\Omega$  series resistors is that they increase the life of the bulbs by limiting the inrush current when the bulbs are first turned on.

Since I used a separate filament transformer, the 5.0 and 6.3 VAC windings in the "plate" xfmr were not used nor did I bring them out. This provides more margin in the HV secondary and the xfmr runs much cooler - it's just barely warm after a 1 hour CW QSO. I stripped the xfmr and bench tested it for several hours under load. The primary and HV secondary leads were reterminated. A 3/8" and 7/16" grommet was added to the top of one end bell to bring out the new primary and HV secondary leads through the top of the xfmr. The end-bells were lightly bead blasted and repainted. The core was repainted. The xfmr's core measures 4-

1/2"H x 3-3/4"W x 2-1/4"D and uses EI-150 laminations. This xfmr came from the "parts unit". The xfmr's wrapper is date coded "4-52" so it is celebrating its 42nd birthday in a new, homebrew, xmtr.



Side view with the side panel and pwr supply PCB removed. The TES enclosure provides relatively easy access to the insides of this xmtr. Note the stacked filter chokes behind the pwr xfmr.

The LLV/LV/HV power supply uses a standard full-wave bridge rectifier with choke-input filtering:

- \* The HV power supply section uses a choke-input filter with a 4 Hy 250 mA Triad C-15X choke. The filter capacitor uses two 47 ufd 450V electrolytics in series. Two 25K 10W resistors are connected across the two electrolytics to equalize the voltage and serve as a bleeder. The resistors equalize the capacitor's voltage by "swamping out" their individual leakage currents. The ARRL Handbook recommends a minimum value of equalizing resistance equal to approximately  $100\Omega/V$  of the individual capacitor voltage. The minimum value can be decreased to increase the bleeder current. The HV key-up output voltage is 620 VDC dropping to 590 VDC when the output is loaded to 100W input (180 mA).

- \* The LV power supply section uses a choke input filter with a 13 Hy 65 mA Stancor C-1708 choke. The filter capacitor uses two 47 ufd 350V electrolytics in series. Two 25K 10W resistors are connected across the two electrolytics to equalize the voltage and serve as a bleeder. The LV key-up output voltage is 310 VDC



dropping to 288 VDC when the output is loaded to 100W.

- \* The LLV for the 1629 "magic eye" tube is obtained at the midpoint of the LV supply's 25K 10W equalizing resistors - about 144 VDC key-down.

- \* The full-wave bridge rectifier is made up of eight 1N4007 1KV 1A diodes. Each diode is shunted by a 560K 1W carbon resistor and 0.001 ufd 1KV disk ceramic capacitor. Even though the bridges Peak Reverse Voltage (PRV) is 2KV, the maximum voltage is limited by the carbon film resistor's 1W maximum continuous voltage specification - typically 500V. Since there are two resistors in series, the bridge's PRV is limited to 1KV continuous. However, the bridge is now capable of 2KV transients. The resistors guarantee voltage division across the 1N4007's in the reverse direction by "swamping out" their individual leakages. Even so, make sure that the rectifier diodes are the same number and manufacturer. The ARRL Handbook recommends multiplying the diodes individual PRV by 500 to determine the value of the swamping resistor. The capacitors guarantee voltage division for voltage transients by "swamping out" the individual junction capacitance. Two 10 $\Omega$  2W resistors are in the bridge leads to the plate xfmr's HV secondary to minimize peak surge/charging currents when the supply is first turned on.

- \* The power supply PCB is single-sided 0.062" pre-sensitized positive acting board material from GC Electronics. It is 3.6"W x 9.0"L. The PCB was laid out 1:1 on a quad-pad, taped on a clear vinyl sheet protector, and the resultant artwork used to expose the board. The etched board was cut to size with a shear. The power supply PCB is mounted against the side-wall of the enclosure. Three AMP 2x3 0.25" box-style Mate-N-Lok connectors on the power supply PCB are used to connect the plate xfmr's HV secondary, filter chokes, and DC outputs. Pins were removed from the connectors to increase the pin-to-pin spacing to minimize voltage breakdown problems and to make the PCB easier to lay out. A jumper plug can be used to change the filter configuration from choke-input to capacitor-input if higher output voltages are desired.

- \* The LV choke is mounted over the HV choke on 2" 8-32 hex spacers to save room.

The metering circuit uses a 0-1 mA Weston model 1521 with dual 0-5 and 0-25 scales. The meter switch has four positions: LV = 0-500V, HV = 0-1KV, GRID = 0-25 mA, and PLATE = 0-500 mA. A small single-sided PCB was designed to accommodate the LV and HV series resistor string. The meter and resistors were bench tested and trimmed to maximize accuracy. A large Mallory 2-pole 5-pos ceramic switch from the "parts unit" was used as the meter switch.

This project required over 70 hours to complete over a three month period, \$103 in parts and material, and \$130 for the TES Industries enclosure.

Like many of my homebrew projects, several friends have contributed parts and labor: Dave Kamlin, AB6XK's WIRELESS WORLD - ceramic plate caps, ceramic 7-pin 1625 sockets, and parasitic

plate suppressors; Dave/AJ70 - ceramic plate caps in addition to the homebrew dual-6GJ5 xmtr that he sold me for \$20 which was the source for many of the major parts for this xmtr; Bradford/N4YYP - 1625's; Barry/N6CSW - 6AG7's and 1625's; Sid/KD6NIM who bent the sheet metal; and Hal/N6ECY - 1629 u-clamp.

Since I did a lot of bench-testing on the various sub-assemblies as this project went together, the long-awaited "smoke test" was without incident or surprises. I had three enjoyable CW QSO's the same day I finished installing the last screw. The xmtr easily loads to 100W input and the output waveform on the SM-220 monitor scope looks pretty clean. The xmtr can be easily loaded to 150W on 40M where I use it the most. The 1625's resting plate current is about 80 mA. The required grid drive is 7-8 mA. The keying characteristics are OK. My first QSO was with Alan, N6RNP, in Paradise, in Northern CA, on 40M. Alan gave me a 589. Dave Mills/AJ70's new QTH in Capistrano Beach is about 30 miles away. Dave gave me a 549. I have had over a dozen CW QSO's with the new xmtr and it has performed very well.

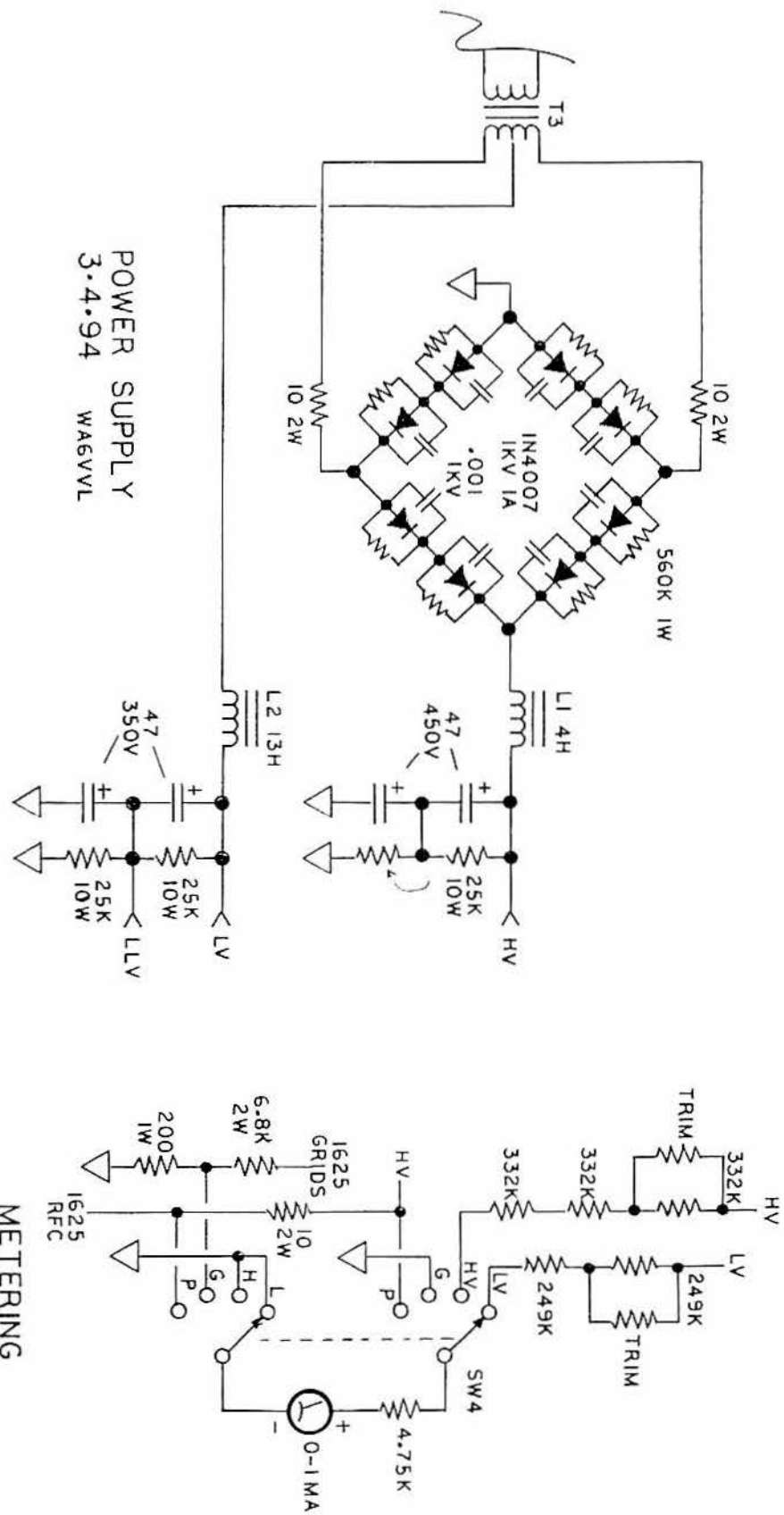
This article was written 2/94 and originally appeared in Electric Radio, May '94, issue #61, "6AG7/1625 100W 5-Band CW Transmitter", pgs.4-9, 34-35.

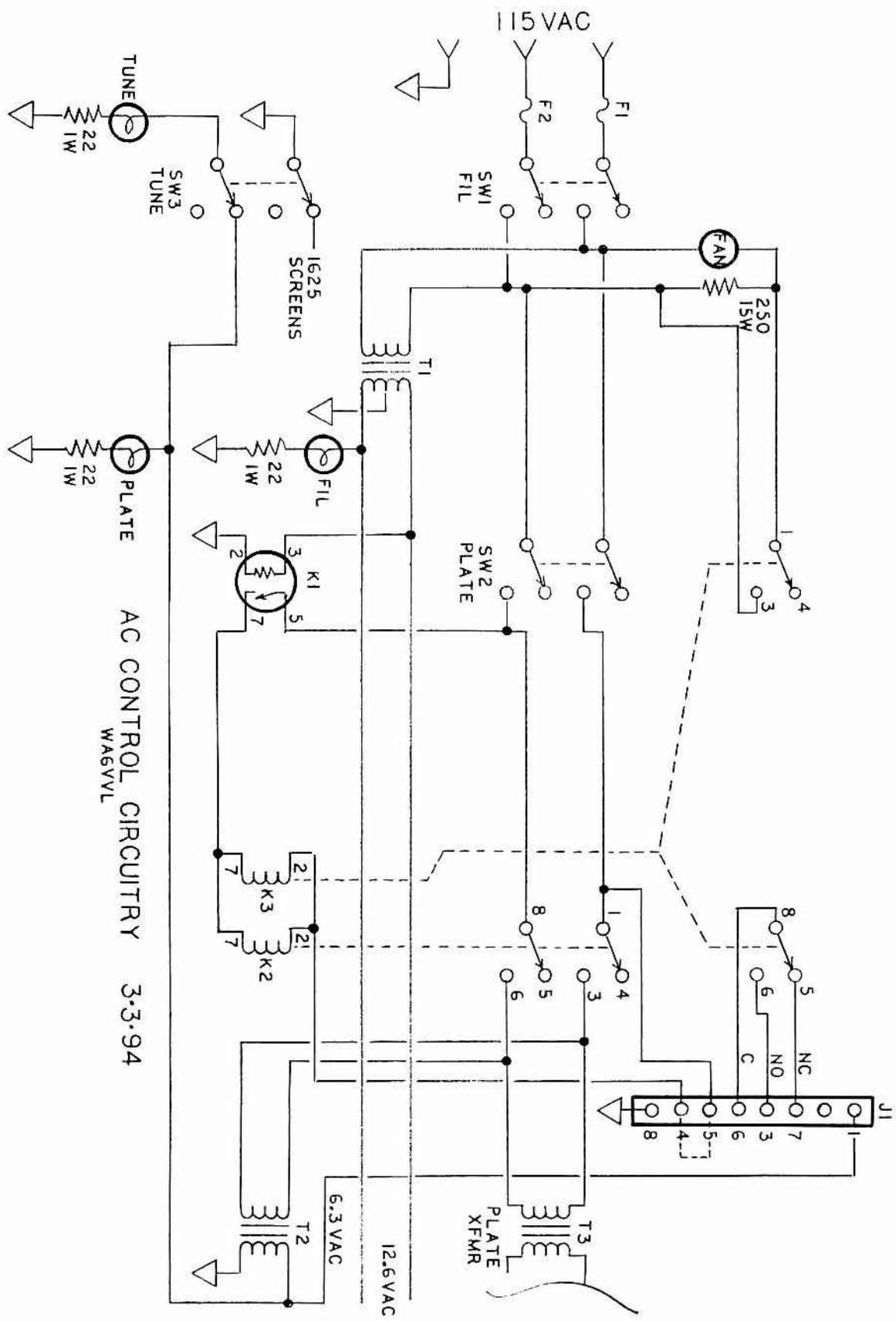
#### Selected References:

1. "RCA 1629 Electron-Ray Tube Data Sheet", Jun.'44.
2. "RCA 6AG7 Power Pentode Data Sheet", Nov.'52.
3. "RCA 1625 Transmitting Beam Power Amplifier Data Sheet", Dec.'44.
4. "807 Transmitting Beam Power Amplifier" RCA Guide for Transmitting Tubes, 1942.
5. "RCA 807 Beam Power Tube Data Sheet", Nov.'54.
6. "RCA Transmitting Tubes", Technical Manual TT-5, 1962.
7. "Simplified Loading of PI Coupled Amplifiers", Norman R. McLaughlin, W6GEG/3, CQ Magazine, Apr.'57, pgs. 32-33, 106, 108.
8. "75 Watts on Four Bands", The Radio Amateur's Handbook, ARRL, 34th Edition, 1957, pgs. 176-178.
9. "A 75-Watt 6DQ5 Transmitter", The Radio Amateur's Handbook, ARRL, 38th Edition, 1961, pgs. 178-181.
10. "A 100-Watt Transmitter", Understanding Amateur Radio, First Edition, ARRL, 1963, pgs. 177-183.
11. "A 150-Watt Amplifier", Understanding Amateur Radio, First Edition, ARRL, 1963, pgs. 183-186.





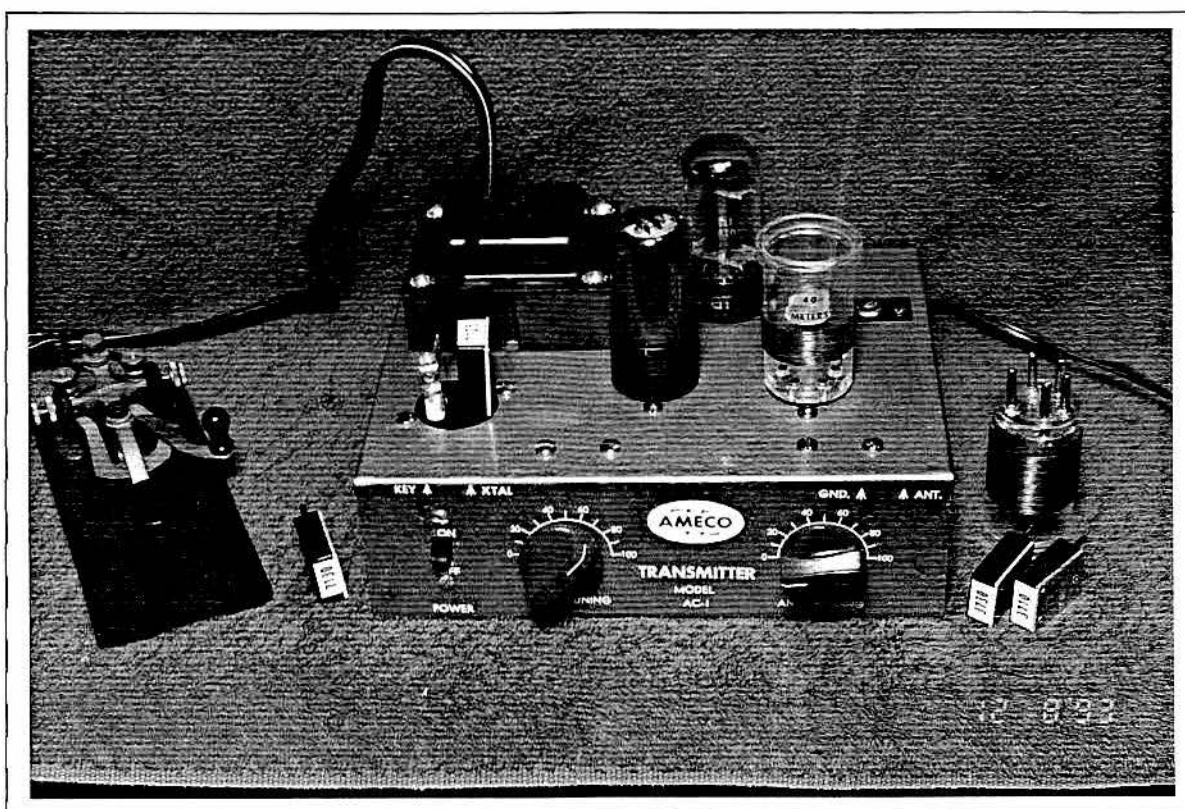




- - - AMECO AC-1 - - -

After the Novice license came into existence in July '51 (read The Pioneering Novices by Jim Musgrove/K5BZH, September '92 ER, pgs. 4-9, 32), several entry-level Novice two- and three-tube CW xmtrs became available. These xmtrs were relatively inexpensive and were designed using open chassis construction. Among the more popular were:

- \* WRL CW-7 - 7W 70L7/50L6 (\$19.95).
- \* Walter Ashe WAT-25 - 80/40M 25W 6AG7/6L6 (\$17.31), w/matching WAP-25 power supply (\$14.23).
- \* Meissner 2-CW - 80-20M 25W 6V6/5U4 (\$24.95).
- \* Philmore NT-200 - 80/40/15M 25W 6V6/6L6/5Y3 w/the power supply built on a separate chassis (\$29.40).
- \* AMECO AC-1 - 80/40M 15W 6V6/6X5 (\$16.95).

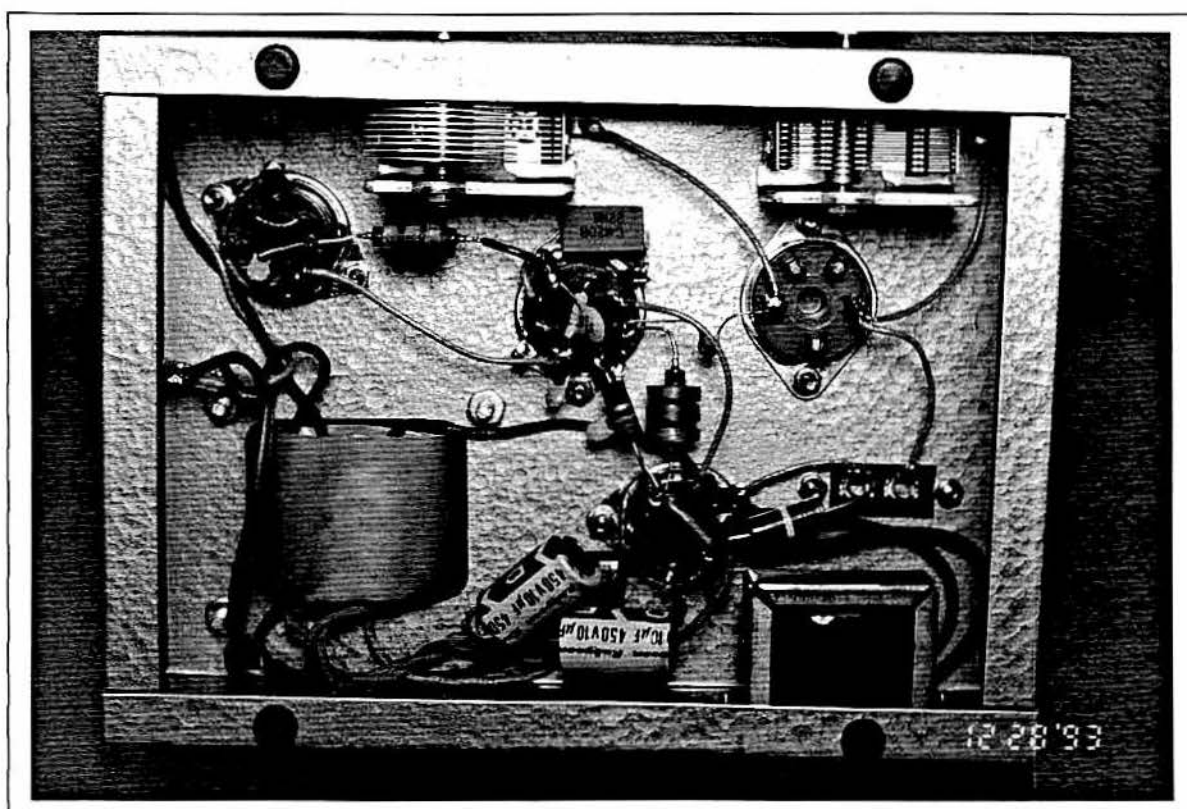


Front view of the AMECO AC-1 with 40M coil installed. This is the original version of the AC-1.

As a fifteen year old Novice in '60, I don't recall ever seeing any of these xmtrs at my ham friend's QTHs. Everyone I knew was into homebrewing xmtrs w/6AG7s, 6V6s, 6L6s, 6DQ6s, 807s, 1625s, and 6146s, or building the more popular Heath, Knight, Eico,.....kits. Of the xmtrs listed above, I clearly remember the Philmore NT-200 and AMECO AC-1 ads. I started out homebrewing xmtrs even before I got my Novice license, so I suspect that I never considered buying either one. It wasn't until I read Randy Barthel/KF8TV's article in the July '93 QST, An "Ocean Hopper"

Reunion, that I started looking into acquiring an AMECO AC-1. I was curious about how well it worked and thought it might make a good collectible next to my own Ocean Hopper (ER#42).

The AMECO AC-1 was first (?) advertised in the '57 ARRL Handbook which means it was probably first available in late '56. The February '57 CQ, pg.66, discussed building the "new Model AC-1 Novice transmitter" in about three hours. In '57, the AC-1 sold for \$16.95 in kit form which included a coil kit for one band, 40 or 80M. Tubes and crystals were extra. An extra coil kit, CK-1, was available for \$0.50. A set of 6V6GT and 6X5GT tubes was \$2.13. By '62, the price had increased to \$19.95 and included the tubes (model AC-1T). AC-1 ads in QST for December '69 and March '70 were \$23.95 and \$24.95 w/tubes. The extra CK-1 coil had increased to \$0.75, \$1 and \$1.10 respectively.



Under chassis view. The 2nd version of the AC-1 moved the coil socket to the rear and used a 2-section variable for ANT. LOADING. The original single-section apparently didn't match "any random length of antenna".

Richard Mintz, the president of the AMECO Corporation, was very helpful in researching the AMECO "archives" for AC-1 information. He sent me copies of the instruction sheets for three different versions of the AC-1:

\* The AC-1 pictured in this article is the original version. The PLATE TUNING and ANT. LOADING capacitors are both 365 uuf. The AC-1 pictured in KF8TV's article in QST is also an original



version.

\* The 2nd version moved the 6X5 closer to the power transformer, more in-line with the 6V6. The coil socket was moved to the rear to make room for a larger 2-section 900 uuf ANT. LOADING capacitor. The 2-screw terminal strip (TB1) for the antenna was rotated 90° to the right side of the chassis. The front panel silkscreen was not changed to correspond with TB1's new location and the GND and ANT labels were now meaningless. The 8 Hy filter choke was eliminated and the 2-section filter cap was changed to a single 20 uf 450V input filter capacitor.

\* The 3rd version changed the plug-in coil to a fixed-coil and used a slide-switch for 80/40M bandswitching. The fixed-coil and slide-switch were installed using a bracket in place of and over the original 5-pin coil socket. The front panel silkscreen was still the same as the original.

The instruction sheets were not dated so it's not clear when these major revisions occurred. The AC-1 ads in QST for December '69 and March '70 still advertised the extra CK-1 coil. It appears that the fixed-coil version was available after '70 (?).

My original AMECO AC-1 is a Novice class, two-tube, 15W input, xtal controlled, single-band 40 or 80M, CW xmtr. A pi-network matches "any random length of antenna". The coil-form included with the kit could be wound for either 80 or 40M. An extra coil kit (CK-1) could be purchased to cover the other band. The coils are wound on standard clear phenolic 5-pin 1-1/4" dia. coil-forms. The 80M winding has 32-1/2 turns and is 1" long (28uH) and the 40M winding has 15-1/2 turns and is 1/2" long (10uH). A 6V6GT operates as a grid-plate crystal oscillator. The power supply uses a 6X5GT as a full-wave rectifier with a capacitor input filter and a 8 Hy filter choke that delivers >330V key down. The key-up voltage is 425V @ 120VAC line. The input and output filter capacitors is a dual-section 8 uf 450V. The power transformer is relatively small, the core measuring only 2-1/2" x 3" x 1". The xfmr runs comfortably warm after several hours of operation.

The AC-1 is built on a 8" x 6" x 2-1/2" gray hammertone finish chassis with white silkscreened lettering. An octal tube-socket on the top of the chassis serves as the xtal socket and key jack. The PLATE TUNING and ANT.LOADING knobs are maroon. A 2-screw terminal strip (TB1) connects the antenna.

I bought my AC-1 from an ER reader who answered my ER#55 ad. The AC-1 was his first xmtr and he purchased it as a kit around Christmas of '69. Judging by the date code on the original 2-section filter cap (820-63) and the original AMECO 6X5 tube (416), this kit may have been packed as early as mid '64. The condition of this AC-1 is really mint. It came with both 80/40M coils w/original AMECO boxes, an extra set of tubes w/original boxes, cable for the key, and the original instructions. All this AND expertly packaged to survive UPS!

Tuning up is pretty straight forward with the exception that there is NO tune up indicator - you have to use an external relative power indicator or a 0-100 ma DC meter in series with the key. Output power measured 7-8W with my Kenwood AT-230 on the 20W range. The xmtr puts out about the same power as my the Heath AT-1 on 80/40M, but using a much smaller footprint/simpler design.

There was very little chirp using 80M xtals but my 40M xtals were a different story. Some of my 40M xtals were quite chirpy, very tuning critical. After PLATE TUNING was adjusted for dip, it was further adjusted for minimal chirp and best keyed waveform on my Kenwood SM-220 monitor scope. My first QSO with the AC-1 was with Dave Mills/AJ70 on 80M. Dave's new QTH is in Capistrano Beach, about 30 miles away. He gave me a 579 RST with just a hint of chirp. Dave reported no key clicks.

Over the years, I have heard some pretty disparaging remarks about the AMECO AC-1. Bottom line? 40M crystals are less forgiving/potentially more chirpy than using a 6AG7, but careful tuning can minimize the chirp. The power supply is more than adequate. I think the AC-1 is a pretty classic 6V6 xmtr and probably works as well as any 6V6 xtal oscillator xmtr can.

### NEW AMECO TRANSMITTER



- Pi-network Output circuit
- Includes Heavy-duty AC power supply
- 6V6 Oscillator and 6X5 Rectifier
- 15 watts input
- For 40 and 80 meters CW
- Crystal controlled
- Attractive grey hammerlone finish with white lettering and red knobs
- Simple and Educational building instructions

**in kit form \$16.95\***  
only

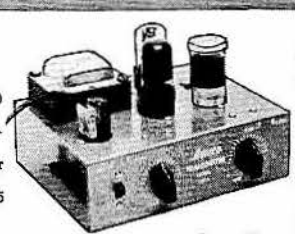
The new AMECO transmitter kit is an ideal unit for the beginner or novice who requires a reliable transmitter. It is a high quality rig containing a heavy-duty transformer-choke power supply. It has a Pi-section output circuit to work into any random length of antenna wire. NO ANTENNA TUNER IS NECESSARY. Keying is clean and chirp-free. TVI suppression features have been included in unit. Kit is low in cost, simple to build, and easy to operate. Units are complete with punched chassis, hardware and instructions.

* Model AC-1 with coil kit for any 1 band, less tubes and crystal.....	\$16.95
Extra coil kit CK-1.....	.50
Set of tubes for above (6V6 & 6X5).....	2.13

### AC-1, NOVICE CW XMTR

Xtal controlled for 40 and 80 meters CW  
Pi-net output ckt, TVI suppressed  
Includes heavy duty AC Power Supply  
15 w. input; 6V6 osc., 6X5 rect.

Mod. AC-1 complete kit for any 1 band .....  
Extra coil kit for other band .....



**\$19.95**

**\$ .75**

Typical '61/'62 AC-1 ad

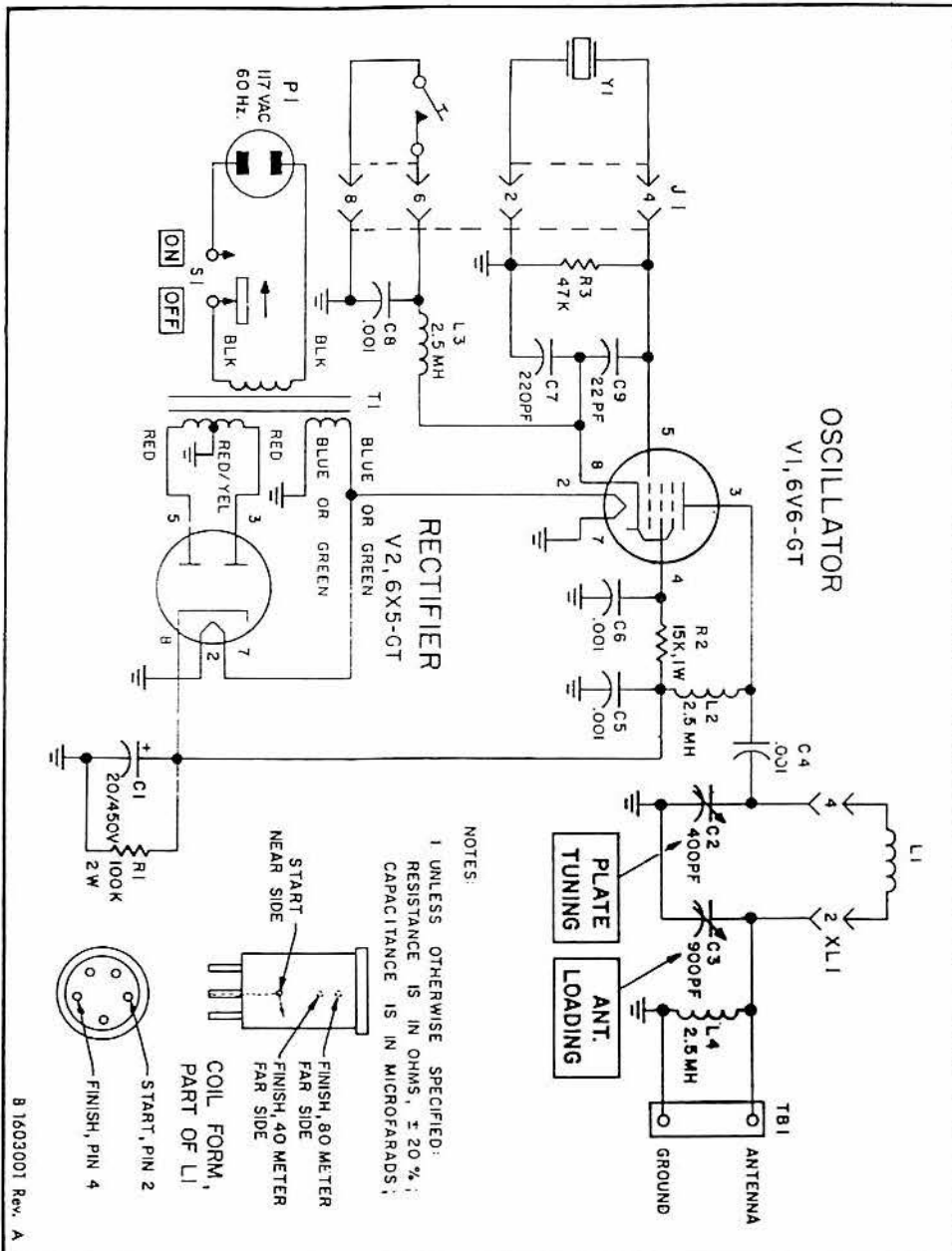
This article was written 11/93. The AC-1 schematic and ads were reprinted with permission from the AMECO CORPORATION.

1957 ARRL Handbook ad

#### Selected References:

1. "New Equipment for the Novice", Novice column, Walt Burdine, W8ZCV, CQ Magazine, Feb.'57, pg. 66.
2. "An "Ocean Hopper" Reunion", Randy W. Barthel, KF8TV, QST, Jul.'93, pgs. 54-55.

## AC-1 SCHEMATIC DIAGRAM



- - - THE CONAR 400 REVISITED - - -

There have been many articles in the pages of ER that have made me curious about equipment that I otherwise wouldn't have thought twice about. Jim Hanlon/W8KGI's article, THE CONAR TWINS, in ER#45 is no exception. I have seen a few of the CONAR 400 transmitters at local swapmeets but I can't recall ever seeing the CONAR 500 receiver. I recently bought a nice CONAR 400 transmitter from an ER reader, Jim Jorgensen/K9RJ, and it turned out to be a real surprise.

The CONAR twins were available from CONAR, a Division of National Radio Institute (NRI), in kit form or assembled. They were also available from NRI as part of their amateur radio home study course. The twins were first advertised (?) in the '65 ARRL Handbook so they were probably available in late '64. The twins were advertised as "new" in both the '65 ARRL Handbook and the '73 ARRL How To Become a Radio Amateur. NRI ads in QST suggest that the twins may have been available through 1980 as part of NRI's Basic Amateur Radio home study course.

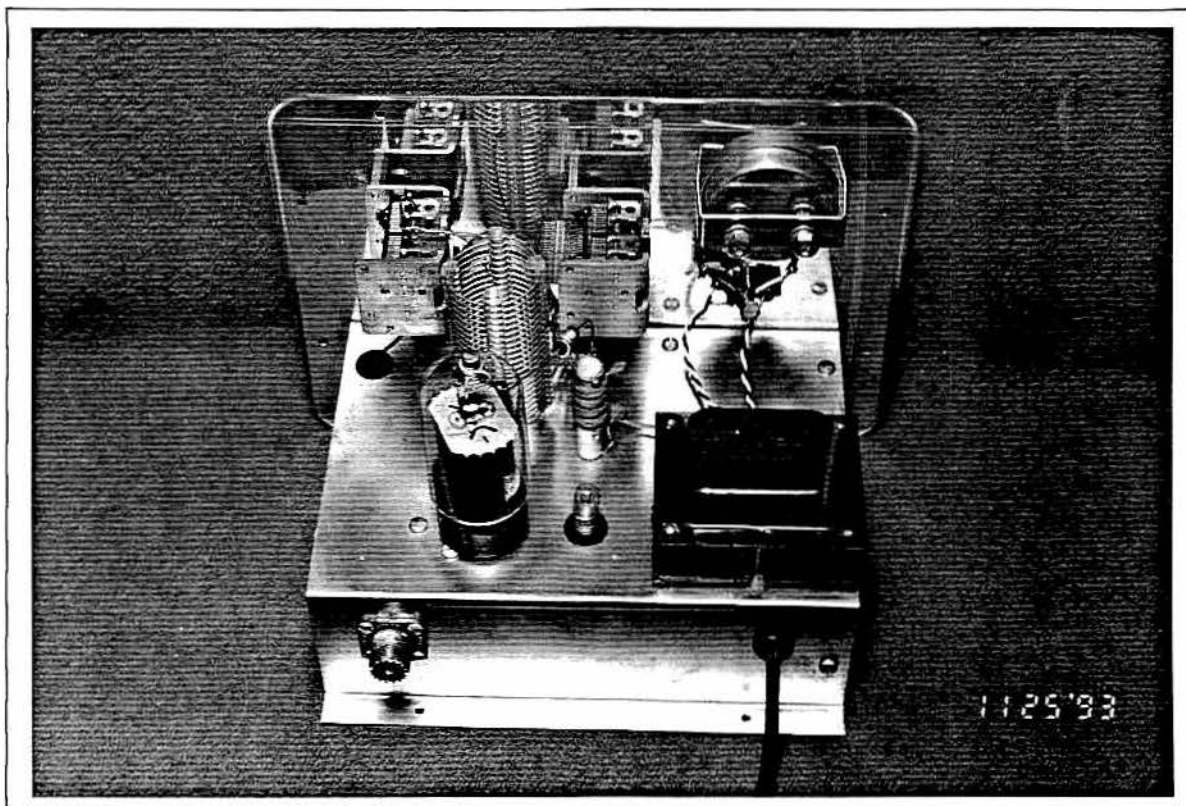


Front view of the Conar 400 80/40/15M Novice CW xmtr.

The CONAR 400 is a novice-class one-tube 6DQ6A 25W, xtal controlled, CW xmtr w/single-knob bandswitching on 80, 40, and 15M. A pi-network matches the antenna. The 6DQ6A operates as a grid-plate crystal oscillator. The power supply uses a solid-state voltage doubler that provides >300V key-down @ 100mA.



Eliminating the "traditional" 5U4G full-wave rectifier tube saves 15W in filament power. As a result, the power transformer is relatively small, the core measuring only 2-1/2" x 3" x 7/8". The output of the voltage doubler uses two 50uf 250V electrolytics. The Hoyt 2-1/4" 0-150 mA undamped meter is in the 6DQ6A's cathode circuit. The xmtr is well bypassed. There is a small light bulb in series with the crystal (CONAR refers to this as a "special variable- impedance current-limiter" that "protects your valuable crystals").



Rear view of the Conar 400. The size of the pwr xfmr was reduced using solid-state rectifiers.

The pi-network is made from two lengths of 1-1/4" dia 8TPI 16AWG miniductor stock (similar to B&W 3018) mounted at right angles to each other. The 15M band uses a separate coil with 6 turns. The 15M coil is in series with the 80/40M coil that has a total of 23 turns. An additional 1000pf SM cap is switched across the LOAD cap on 80M. The TUNE and LOAD caps are standard 2-section "broadcast variables" - the TUNE cap using only one of the sections.

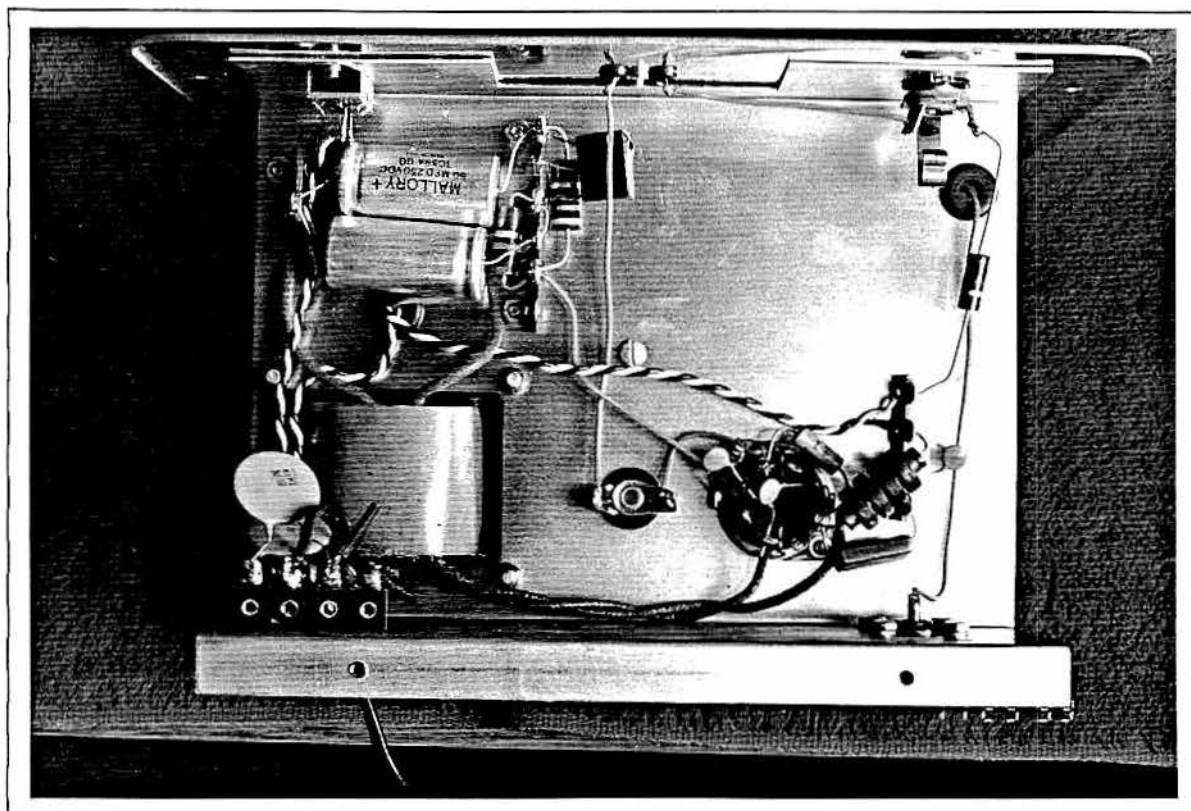
The xmtr is housed in a 9-7/8"W x 7-1/2"H x 6-3/8" dark- blue hammertone steel cabinet. The front panel is thin gauge brushed-steel with bright red silkscreened lettering.

The xmtr easily tuned to 25-30W input power with 13-16W output. The xmtr puts out more power than the Heath AT-1 but using a



smaller footprint/simpler design.

There was very little chirp using 80M xtals but my 40M xtals were a different story. Some 40M xtals were quite chirpy, very tuning critical. After TUNE was adjusted for dip, it was further adjusted for minimal chirp, best keyed waveform on my Kenwood SM-220 monitor scope, and minimal xtal currents. At some settings of TUNE, xtal currents were quite high as evidenced by the brilliance of the xtal lamp and xtal heating. It's too bad that the xtal lamp isn't mounted on the front panel because it's a very useful tuning indicator.



Under chassis view. The power supply uses a standard solid-state voltage doubler.

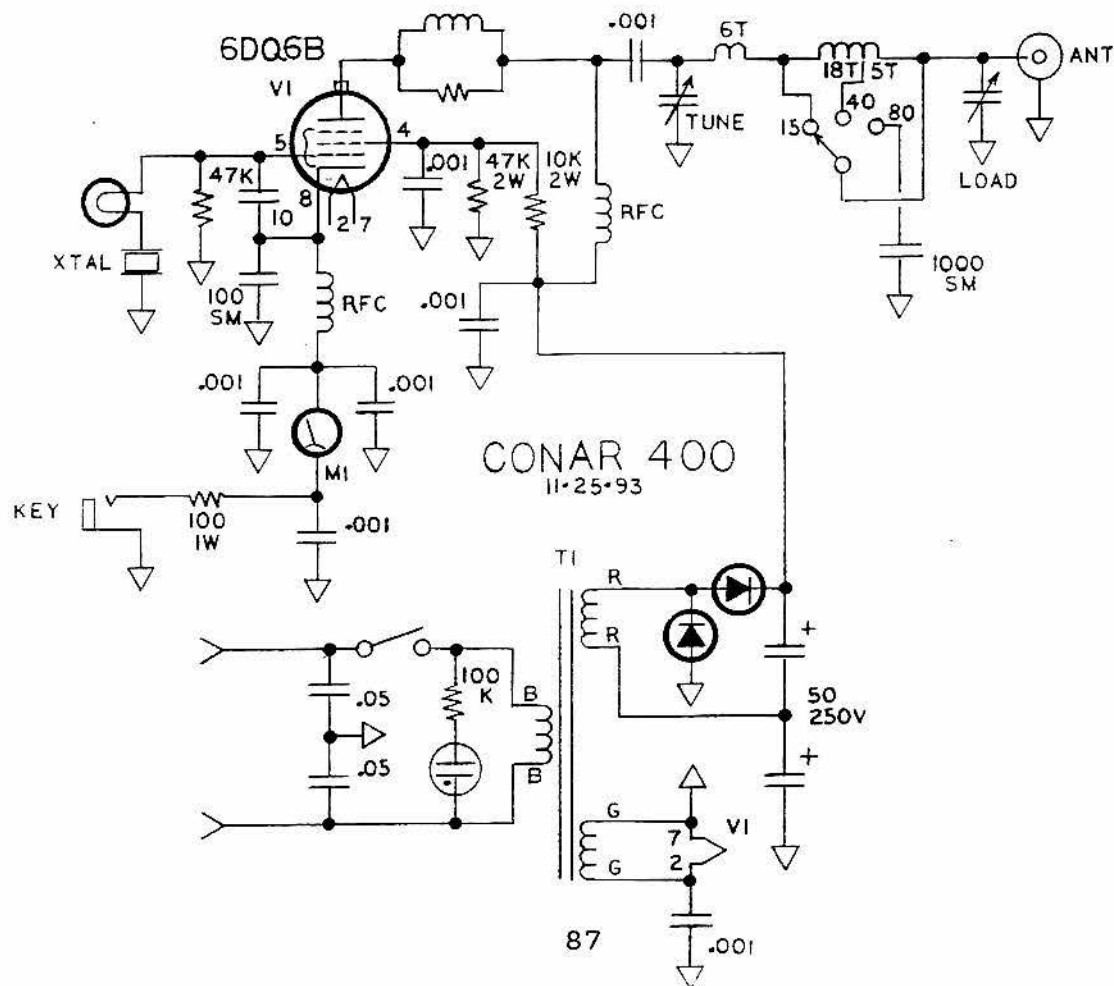
The Conar 400 turned out to be a real "time machine". As Jim, W8KGI pointed out in his original article, the 400 is very similar to the article by Lewis G. McCoy, W1ICP, A Three-Band One Tube Novice Transmitter, in the December '57 QST, pgs. 34-37. This is the article that I used to build my early novice xmtrs from '60-'62.

Unfortunately, not all of my xmtrs worked very well. Oh they (kind of) worked, but they sure left a lot to be desired, especially in their keying characteristics. I spent hours building them, planning every screw hole, every part location, every.....Then came the "smoke test" and disappointment. I got so good at building good looking, mediocre, 6DQ6 xmtrs that it got

I would have never guessed that an article in Electric Radio would have answered questions that were 30 years old. I think I will renew my subscription to Electric Radio!

### Selected References:

1. "A Three-Band One Tube Novice Transmitter", Lewis G. McCoy, W1ICP, QST, Dec.'57, pgs. 34-37.
2. "A Simple One-Tube Transmitter", How to Become a Radio Amateur, Twenty-third Edition, ARRL, 1964, pgs. 76-91.



- - - HEATH DX-20 - - -

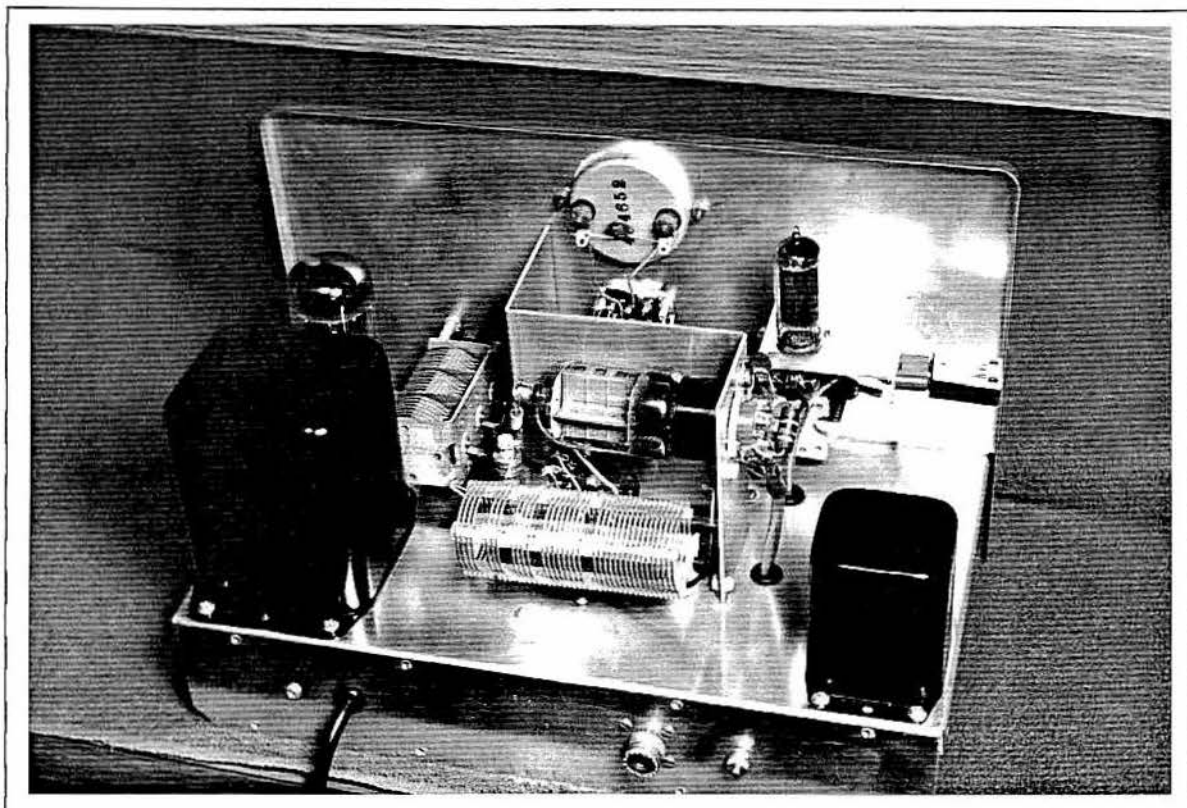
In spite of my recent "infatuation" with Heath's AT-1 xmtr (ER#50), Heath's DX-20 was the first kit-type xmtr that I used as a Novice in 1960. I used Alan Burgstahler/WA6AWD's DX-20 for literally hundreds of my Novice and Conditional QSOs. I spent many a weekend at Alan's house in Desert Hot Springs, CA, using his DX-20 and HQ-100 into the early morning hours, occasionally waking him up to copy code that was too fast for me to copy. After building several so-so homebrew xmtrs, I looked forward to using Alan's DX-20 on the weekends. I will always have fond memories of the Heath DX-20.



Front view of the Heath DX-20 CW xmtr. The DX-20 sold for \$35.95 when it was introduced around Christmas of 1956.

The DX-20 is a 50W input, xtal controlled, CW xmtr w/single-knob bandswitching on 80-10M. The pi-network will accommodate output impedances in the range of 50-1000 ohms. I have often referred to the DX-20 as a 2nd generation AT-1. While the DX-20 was the replacement for the AT-1, it was NOT an "improved" AT-1. The DX-20's design was brand-new, both mechanically and electrically. The DX-20 sold for \$35.95 when it was introduced around Christmas of 1956. The DX-20 uses a 6CL6 Colpitts oscillator, 6DQ6A final amplifier, and 5U4GB rectifier. The power supply uses a choke input filter that delivers >500V key-down @ 100 mA. To further improve regulation, the filter choke is tuned with a 0.1 uF

capacitor which limits the surge voltage under key-up conditions. Since the 6CL6 and 6DQ6A are mounted on shields and brackets above the chassis, most of the oscillator and amplifier wiring is above the chassis. The under-chassis wiring has been kept to a minimum. The 6DQ6A is horizontally mounted.



Rear View of the Heath DX-20.

Although this is a very simple and straight-forward CW xmtr to operate, I have a few minor (?) criticisms:

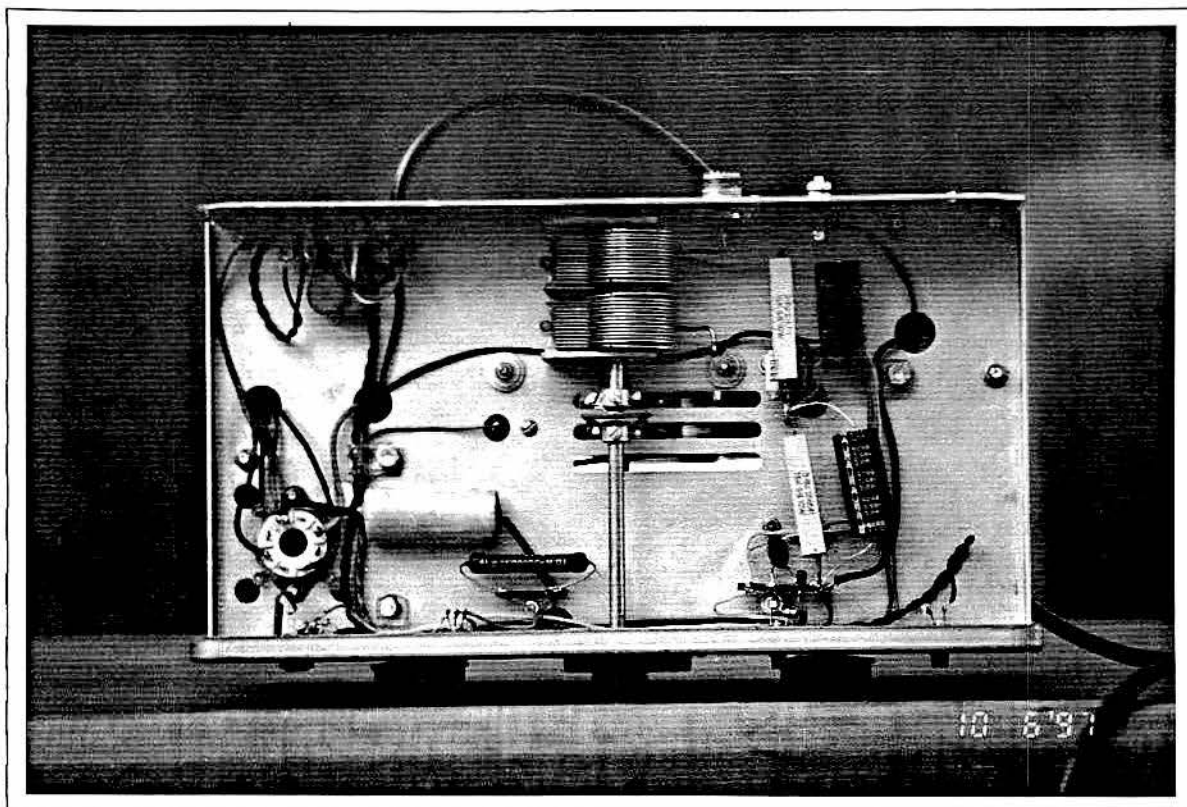
- \* Changing the xtal is through a hole-plug on the left side of the xmtr. The xtal location is (probably) OK if you have only one xtal, but if you have several and change bands frequently, it's a nuisance which precludes mounting the DX-20 under a shelf to the right of the rcvr. In addition, placing the xtal inside the DX-20 will cause a short-term frequency drift of several hundred Hz as the xtal heats to the DX-20's internal temperature. I personally prefer the front-panel mounted xtal sockets a la Heath AT-1, Johnson Adventurer, Drake 2N-T, etc.

- \* The meter is the same undamped type found in the AT-1 and DX-35 which makes tune-up a real "chore". Unlike the AT-1, the DX-20's meter switch has no mid-position that switches out the meter. Like the AT-1, I'm always afraid that the meter is going to "beat itself to death"/"self-destruct" (although I can't remember ever worrying about that when I used Alan's DX-20 thirty years ago!).

- \* The DX-20's power xfmr doesn't appear to be very reliable. My DX-20's power xfmr failed several months after I bought it - the HV secondary shorted. I replaced the xfmr from a DX-20 "parts



unit" whose xfmr had been replaced by Heath. I have also seen several DX-20s at TRW sans xfmrs.



Under chassis view of the Heath DX-20.

I bought my DX-20 from Bill Albrant/K7JYE 2-1/2 years ago. It was in very good condition and didn't need any major work aside from filter caps and line cord. It is now a somewhat composite unit, having the best parts from three separate units. It is a "permanent" part of my collection that I occasionally use with my SX-100.

This article was written 11/93 and originally appeared in Electric Radio, Nov.'93, issue #55, "The Heath DX-20", pgs. 30-31.

Selected References:

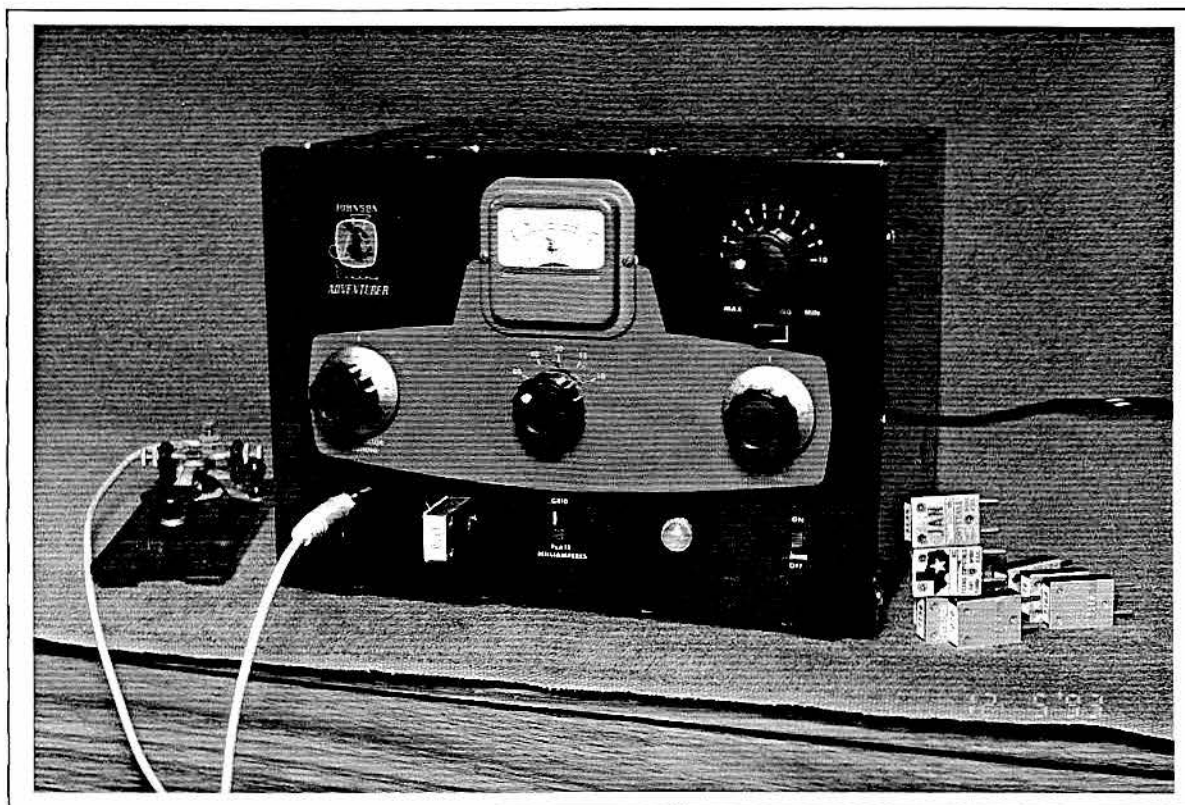
1. DX-20 Review/Novice Column, Donald L. Stoner, W6TNS, CQ Magazine, Apr.'57, pgs. 60-61, 96.



- - - THE E.F. JOHNSON VIKING ADVENTURER - - -

Sitting alongside the Heath AT-1 in terms of classic xmtr designs right out of the pages of CQ, QST, or the Radio Handbook, is the E.F. Johnson Viking Adventurer. A classic 6AG7/807 CW xmtr, the Adventurer was first sold in 1954 and 6,142 were built before being discontinued in 1964 (ER#27, pg.11). In '54, the Adventurer sold for \$54.95 in kit form which was a bit "pricey" compared to the Heath AT-1's \$29.50 and later, the DX-20's \$35.95. A separate speech amplifier/modulator was available for \$12.25. By the time the Adventurer was discontinued in '64, the price had increased to \$69.95.

The Adventurer is a 50W input, xtal controlled, CW xmtr w/single-knob bandswitching on 80-10M. The pi-network will accommodate output impedances in the range of 50-600 ohms. A MIN/MAX slide-switch on the front panel adds a 700pF SM cap across the 700pf COUPLING cap in the MAX position. An RCA phono jack is used for the antenna output. The tube line-up consists of a 6AG7 pierce-type crystal oscillator (serves as a buffer when an external VFO is used), 807 final amplifier, and 5U4G full-wave rectifier. The 807's socket is mounted 1" below the chassis which helps limit the front panel height to 8-1/8".

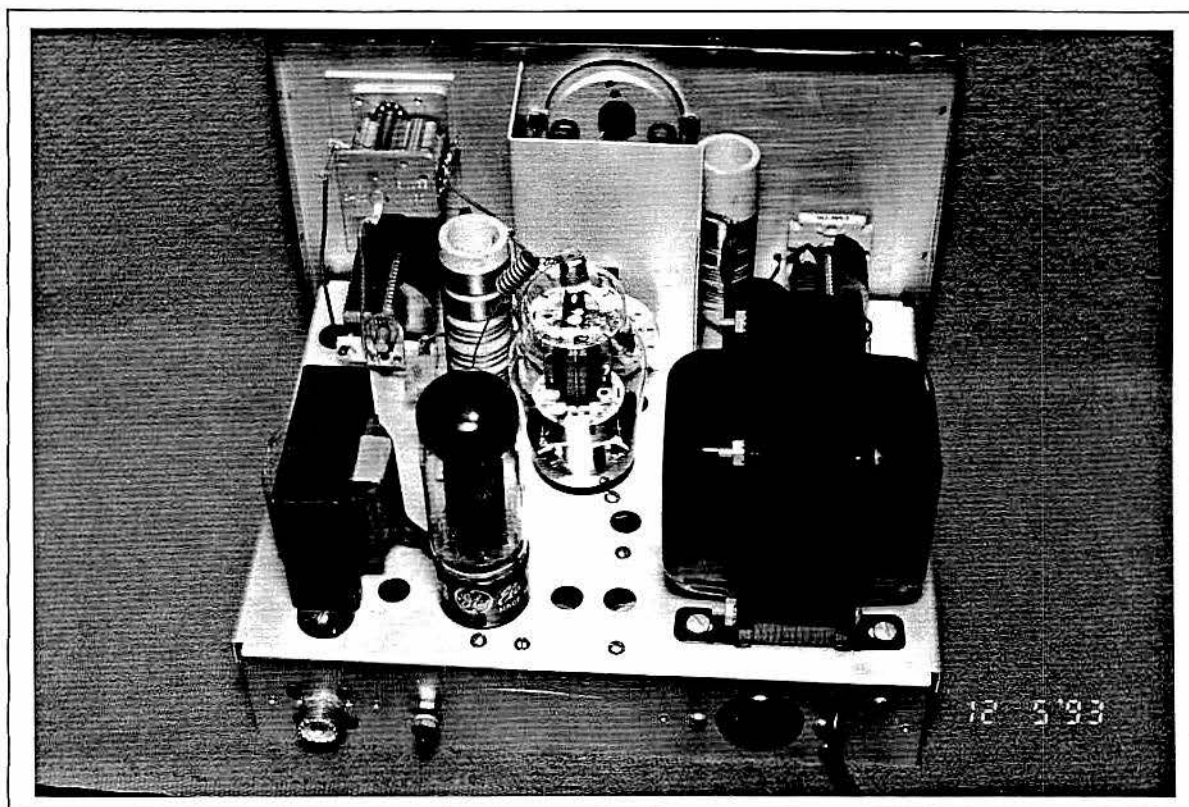


The front view of the E.F. Johnson Viking Adventurer. The Adventurer sold for \$54.95 when it was introduced in 1954.

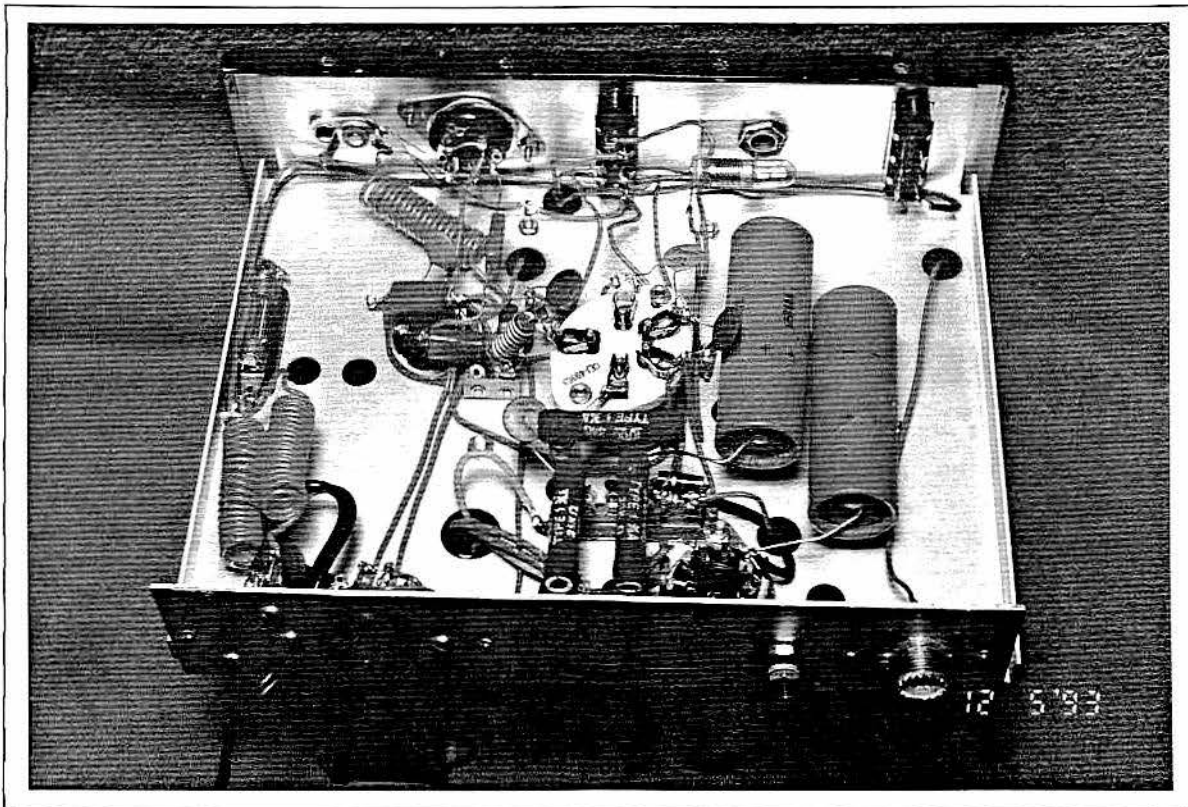
The power supply uses a capacitor input filter and filter choke that delivers >475V key-down @ 100 mA. The input and output filter capacitors are both 8 uf @ 700V. The 20K/25K divider/bleeder across the output of the power supply provides 200V for the 6AG7. The Adventurer's pwr xfmr uses the same lamination as the AT-1's xfmr and has about 1/4" more iron in the core - not exactly a "husky" supply for the 50W input power.

A dual-scale (0-20 mA/0-200 mA) undamped 2" meter indicates 807 grid or plate current. The xtal or VFO input uses an octal socket mounted behind the front panel. An accessory socket is available on the rear apron for powering the Johnson (or similar) remote VFO. The Adventurer's point-to-point wiring is very clean and straightforward and I suspect that it would have been a relatively easy kit to build.

The Adventurer is housed in a 10-3/8"W x 8-1/8"H x 7-3/8"D maroon aluminum cabinet. The front panel is aluminum and painted maroon and gray with green silkscreened lettering. The xmtr is utilitarian in appearance - not as cosmetically pleasing as (say) the Heath DX-20/DX-35 with their rounded-corner cabinets. The Adventurer is about 17% and 20% smaller than the AT-1 and DX-20 respectively.



Rear view. Note that the 807 is mounted 1" below the chassis to minimize the Adventurer's front panel height. The RCA phono jack has been replaced with an SO-239 connector.



Under chassis view.

The Adventurer pictured was bought from an ER reader, Bob Braeger/WA6KER. It had a few "battle-scars", but generally speaking, it was in very good condition. It was original with the exception that the RCA phono jack had been replaced with a std SO-239 antenna connector. For \$54.95, you would have thought that E.F.Johnson would have used an SO-239 in the first place! I removed the front panel and gave it several coats of Meguiar's Car Cleaner/Wax to bring out the original finish. The front panel hardware was replaced. Input power on 80/40M was just under 50W. Output power was 20-22W.

This article was written 12/93.

Selected References:

1. "Recent Equipment - The Viking Adventurer", QST, Aug.'55, pgs. 39-40.



- - - HEATH DX-40 - - -

The Heath DX-40 was, as Marty Drift/WB2FOU might say, the last of the Heath "gray gear". A 2nd generation DX-35, the DX-40 was first advertised in January '58, and lasted slightly less than three years when it was replaced by the DX-60 in November '60. The DX-40 sold for \$64.95. Heath could supply very little information about the DX-40 when I wrote them in '85.

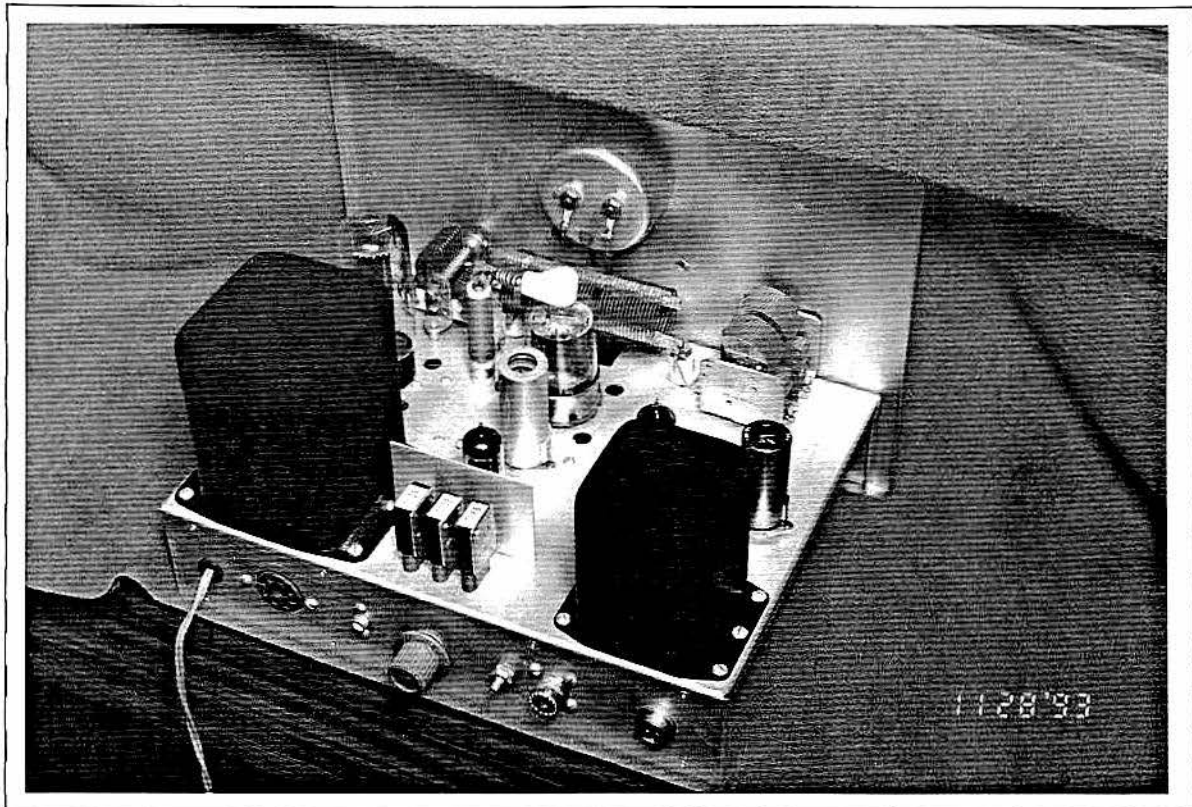


Front view of the Heath DX-40.

The DX-40 is a 75W CW, 60W AM, xtal controlled, CW/AM xmtr with single-knob bandswitching on 80-10M. The pi-network will accommodate output impedances in the range of 50-1000 ohms. The tube line-up consists of a 5U4GB full-wave rectifier, 6CL6 Colpitts crystal oscillator (serves as a buffer when an external VFO is used), 6CL6 buffer, 6146 final, 12AX7 speech amplifier, and a 6DE7 controlled-carrier modulator (the older DX-35 used 12BY7s for the oscillator and buffer and a 12AU7 for the modulator). The power supply uses a choke-input filter (7Hy) that delivers >580V key down @ 125 mA. The output filter capacitors are two 40uF 450V electrolytics in series. The two 20K 10W equalizing/bleeder resistors are mounted on the top of the chassis, keeping their heat away from the filter caps. An accessory socket is available for powering the Heath VF-1 (or similar) remote VFO.

A dual-scale (0-6 mA/0-150 mA) fully damped 2-1/2" meter indicates 6146 grid or plate current. A 2-pole 4-position switch

on the rear chassis selects between three xtals or an external VFO. Xtals can be accessed through a "trap door" at the rear of the cabinet. The DX-40's point-to-point wiring is very clean and I suspect it would have been a good kit to build.



Rear view. The switch on the rear apron selects external VFO operation or one of three FT-243 xtals.

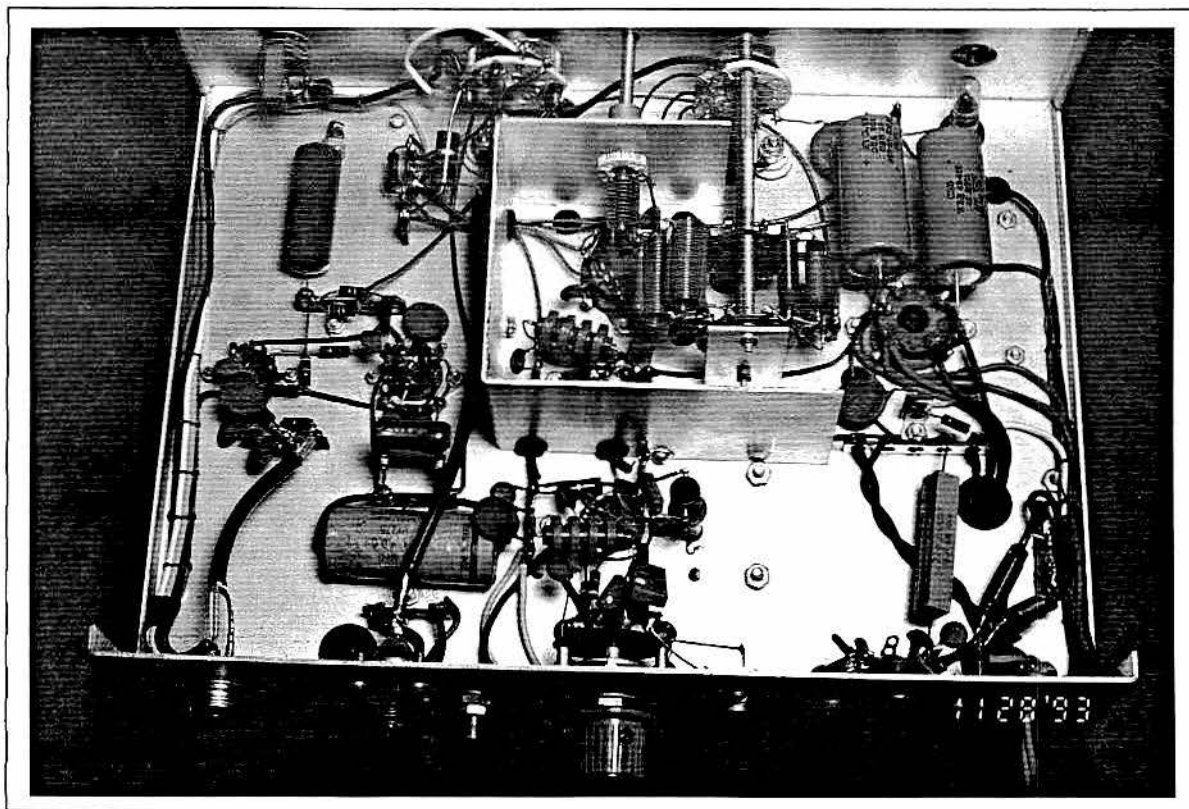
The DX-40 pictured has a long history. I traded it for a DX-60 at the local TRW swapmeet in '85. I fully intended to completely rebuild it but dragged my feet until I found another "parts unit" in '91. As it turned out, the "parts unit" was in pretty good shape and included three 40M xtals. I stripped the knobs, meters, panels, and tubes from both units and made a composite DX-40 from the best parts.

I have used this xmtr on CW and prefer it over the DX-20 only because of the damped meter - tune-up is so much faster. Dave Mills/AJ70 gave me good AM signal reports using an amplified-base D-104 mic so I have not modified the speech amp. I replaced the Amphenol mic connector with a standard 4-pin mic connector. I returned the mic ground to the speech amp socket to eliminate hum on the carrier in the AM mode.

A minor criticism is the location of the crystals. I still prefer xtal control for my novice-type xmtrs and have several dozen xtals to choose from. Changing the xtals from the rear, three at a time, and then trying to remember the position of the rear-mounted



xtal switch is a real pain. The DX-40 was designed primarily for VFO operation. The 3-position xtal switch allowed novices to use the DX-40 until they upgraded and started using a VFO. Xtal control was a "temporary" operating mode.



Under chassis view.

This article was written 11/93.

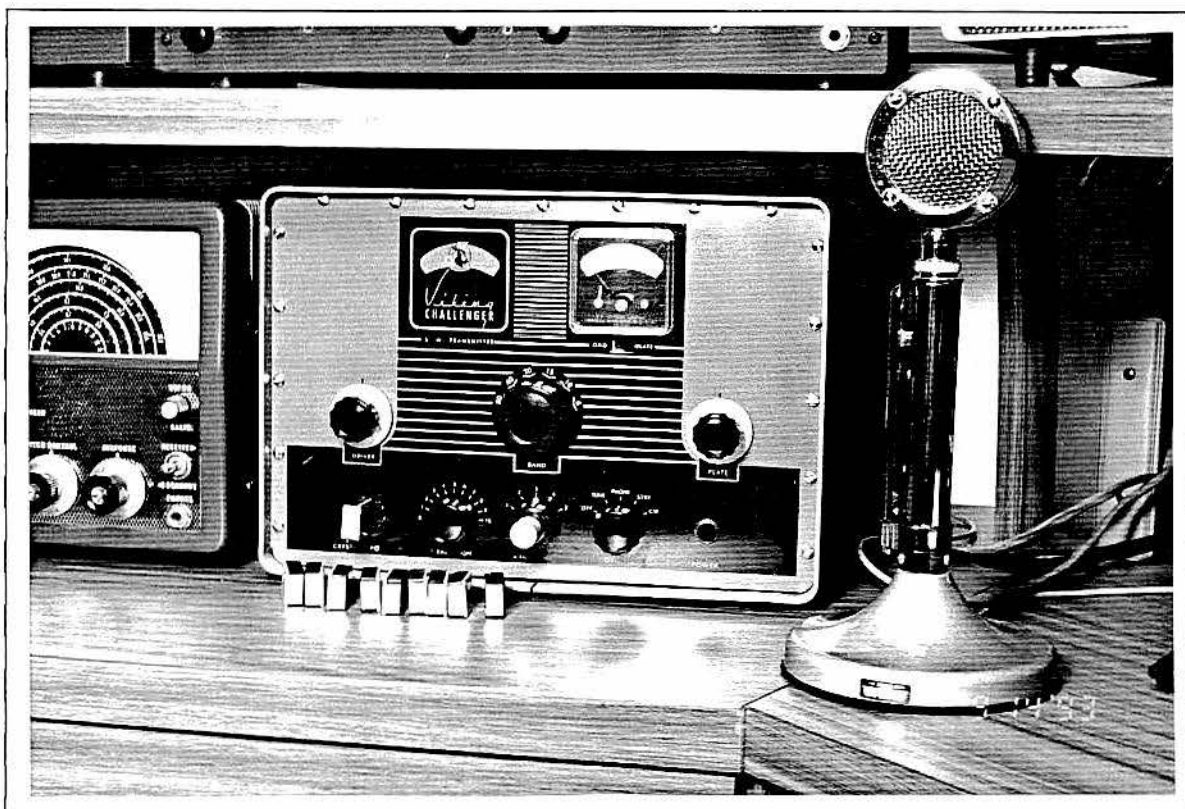
Selected References:

1. "Recent Equipment - The DX-35 Transmitter Kit", QST, Sep.'56, pgs. 28-30.
2. DX-40 Review, Novice Column, Donald L. Stoner, W6TNS, CQ Magazine, Mar.'58, pgs. 68-70.
3. "Plate Modulating The DX-40", L.J. Haycock, K8JMW, CQ Magazine, Dec.'60, pgs. 52-53.

- - - THE E.F. JOHNSON VIKING CHALLENGER - - -

Although my first homebrew CW transmitter used a 6AG7 on 80/40M, most of my early CW xmtr designs revolved around the 6DQ6 sweep tube (Lewis G. McCoy/W1ICP, A Three-Band One Tube Novice Transmitter, QST, December 1957, pgs. 34-37 or 1961-65 ARRL Handbook).

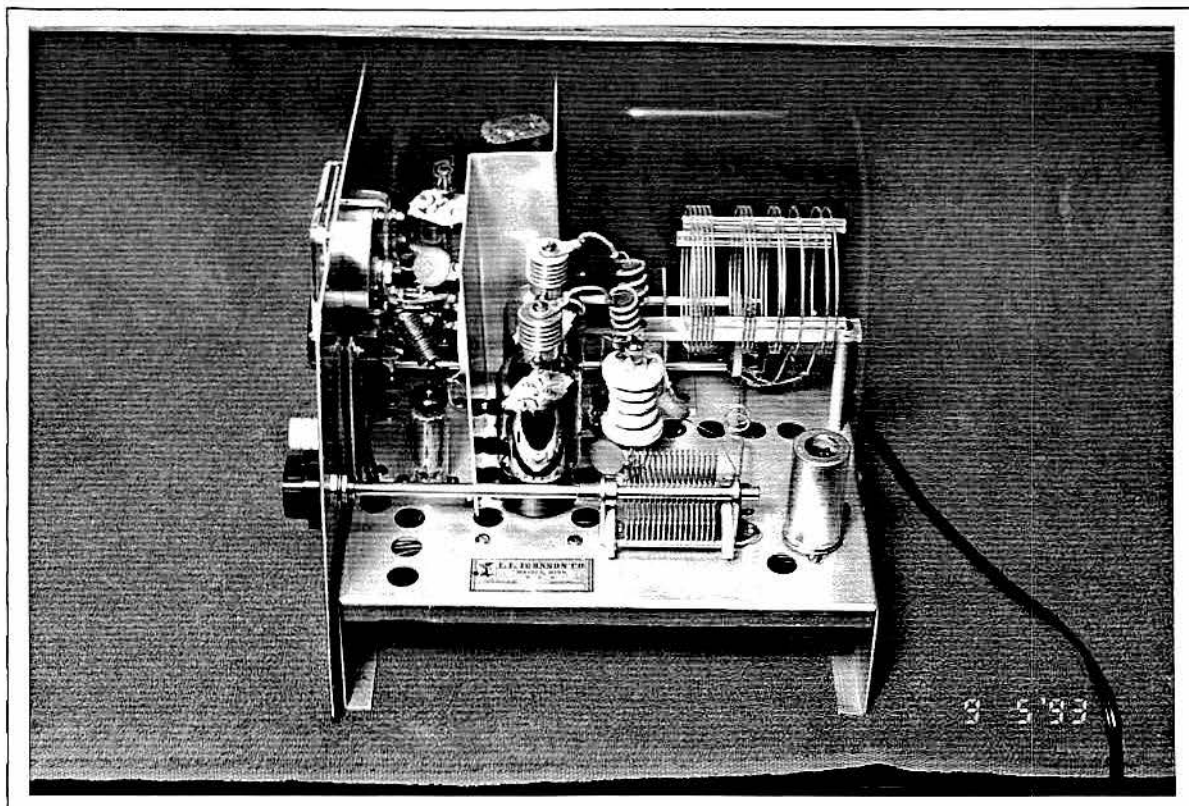
Junk B&W TVs were plentiful in the early 60s so there was no shortage of power supply components AND sweep tubes. I'm sure I had some access to "real" RF tubes, but the 6DQ6 became my tube of choice for several years. I may have been more than a bit biased after using WA6AWD's DX-20 (ER#55), which used a 6DQ6A in the final, for many of my novice and conditional QSOs. In any event, I used 6DQ6s in most of my homebrew xmtrs from '60-'62.



Front view of the E.F. Johnson Challenger. The front panel was rubbed-out/polished with Meguiar's Car Cleaner/Wax. The knobs and meter face were polished with Novus #2 Plastic Polish. The amplified-base D-104 works quite well with the Challenger.

It was this background that made me curious about the E.F. Johnson Viking Challenger. The Challenger is the epitome of a sweep tube rig - 2 6DQ6Bs in the final driven by a single 6DQ6B. The Challenger is a 120W CW, 70W AM, xtal controlled, CW/AM xmtr with single-knob bandswitching on 80-6M. The pi-network will accommodate output impedances in the range of 40-600 ohms using a

coarse/fine loading network. The balance of the Challenger's tube line-up consists of a 6DS5 crystal oscillator, 12AX7 speech amplifier, 6AQ5 clamp/screen modulator, and a 5U4GB rectifier. The power supply uses a choke input filter that delivers 580 VDC key-down at 220 mA. The power transformer is "huge" - Johnson did not skimp on iron in the xfmr.



Side view. The parallel 6DQ6B's were visible as are most of the output RF components. The 12AX7 speech amplifier is behind the PLATE tuning capacitor. The 6AQ5 clamp/screen modulator is in front of the 6DQ6B's.

The Challenger was first sold in 1958 and was sold through 1966 when E.F. Johnson ceased production. A total of 3,836 were built (ER#27, pg.11). The tubes in my Challenger were original, and based on the 63-03 date codes of the 6DQ6Bs, this rig was sold as early as 1963. The Challenger sold for \$114.75 in kit-form or \$154.75 wired and tested.

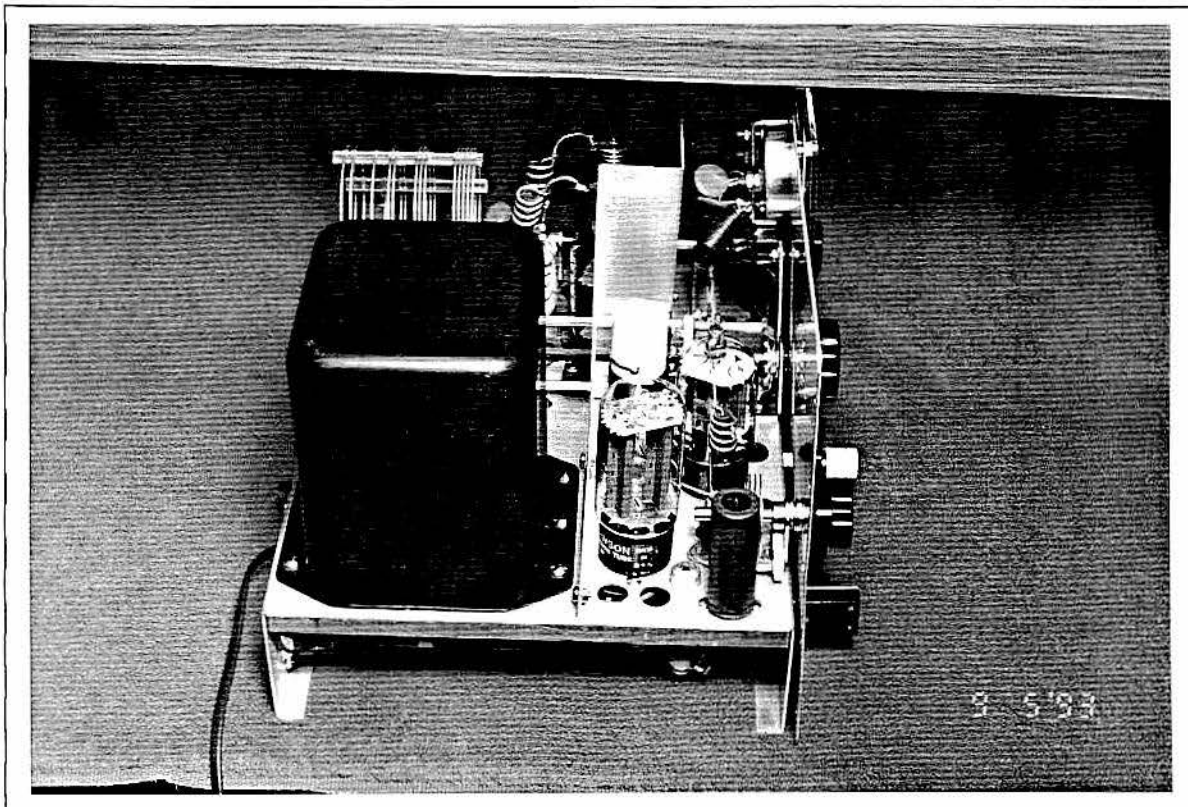
My Challenger arrived via UPS with considerable "shipping damage". The front panel was badly bent, both 6DQ6B finals were broken, and the internal aluminum shield was very loose with missing hardware. **The damage was caused by poor packaging and NOT UPS!** The front panel is made from relatively soft aluminum and was easily straightened. After straightening, I rubbed it out with several coats of Meguiar's Car Cleaner/Wax. Aside from a few minor scratches, the panel looks almost new - I was quite pleased with the results. The meter face and knobs were cleaned with Novus



Plastic Polish #2. I spent several hours repairing the shipping damage before turning my attention to the Challenger's operation.

Before powering up the Challenger, I checked the leakage of the original 80 ufd 450V filter caps. Both were leaky and needed replacement. When I replaced the filter caps, I ended up completely rewiring the power supply, from the line cord to the filter caps - one thing just led to another.

While the Challenger's layout above the chassis appears to be pretty reasonable, the wiring below can best be described as "cluttered". Many of my vintage xmtr kits are pretty good examples of clean, well thought out, point-to-point wiring. The Challenger, however, is NOT one of them. In addition, I didn't need the 240-182-1 P/N on the S/N tag to figure out that it wasn't factory wired. I didn't rewire it but I spent several hours cleaning up the "rough spots".



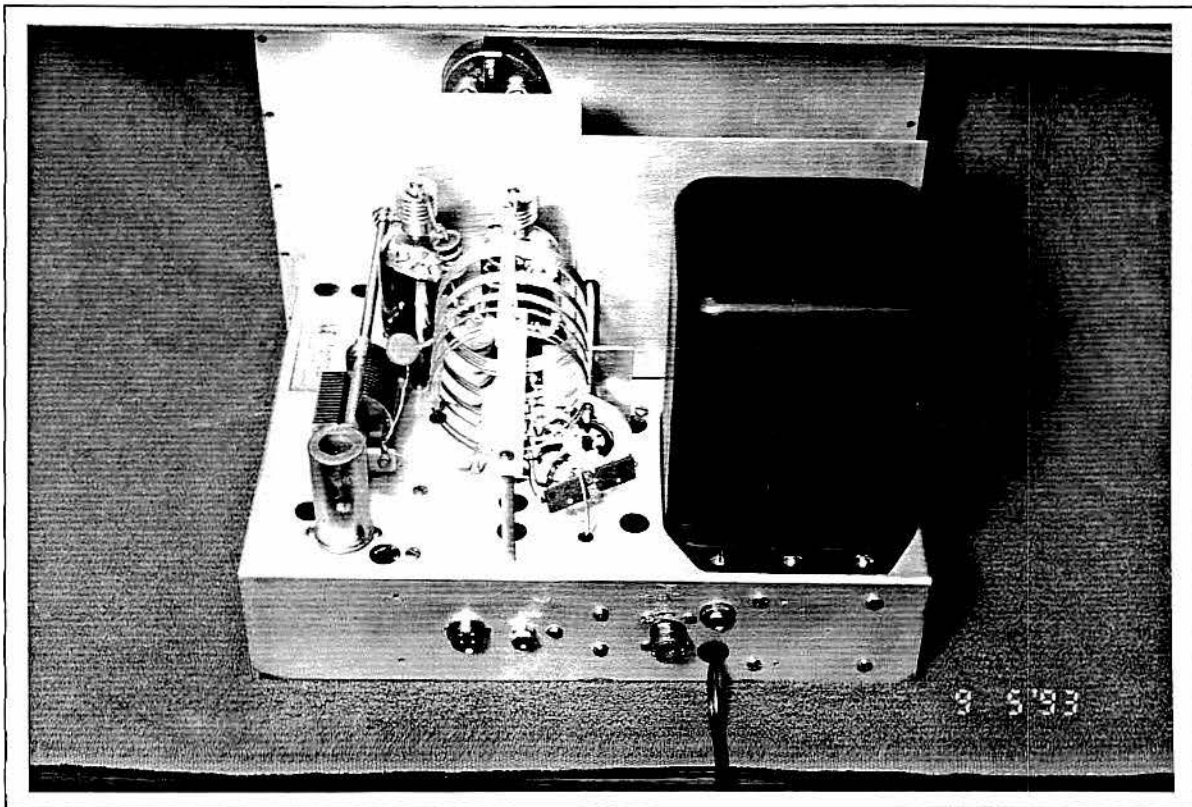
Side view. Note the size of the pwr xfmr. The 6DS5 crystal oscillator, 5U4GB rectifier, and 6DQ6B driver are in front of the pwr xfmr.

Bringing the Challenger up on a variac revealed no obvious problems but something under the chassis was sure hot. Both R28 (10K 10W) and R25 (40K 15W) ran unreasonably hot. R28's calculated power dissipation in the CW mode, key-up, is 10.9W, and 19.8W in AM. R25 dissipates 10.2W. I replaced two of the power transformer's mounting screws with 10-32 x 2-1/2" screws and used

these screws to vertically mount R25 and R29 (30K 20W). The 10-32 screws act as a heatsink for R25/R29. I replaced R28 with a 10K 25W. The Challenger's power supply wiring is no longer "stock" but it no longer smells like it is "burning".

One of the first things I did was to get a signal report on 80M CW from Dave Mills/AJ7O. Dave is about 7 miles away and he gave me good tone reports but said that the Challenger "keyed a bit soft". At 100W output, Dave could just hear the xtal oscillator being keyed but said that it wasn't bad. My first CW QSO with Millard, KB7NYB, also received a good signal report. The keyed waveform on my Kenwood SM-220 monitor scope looked OK. Since only the 6DS5 crystal oscillator and 6DQ6B driver are keyed (approximately 33 mA key-down), I had no problems keying the Challenger with my solid-state HK5A keyer.

The original audio input RCA phono jack had already been replaced with a 1/4" phone jack so I made the hole a tad larger and installed a standard 4-pin microphone connector to fit my amplified-base D-104. Switching to AM, Dave said the audio sounded "restricted". I changed the 0.001 ufd coupling caps to 0.015 ufd and replaced the two 10 ufd cathode bypass caps. Dave now gave me a good audio report and said that I sounded more natural. I also received good audio reports from a round-table AM QSO later in the week.



Rear view. The mic connector was changed to a standard 4-pin mic connector to fit the amplified base D-104 mic.



The maroon cabinet was beyond just touching-up so I repainted it gray wrinkle to semi-match my SX-100.

The Challenger is now sitting beside my SX-100 and is used primarily for CW. I'm keeping the Viking 1 for my AM QSOs. The Challenger is relatively fast and easy to tune and input power easily exceeds 120W on CW. The off-resonance plate current is almost 400 mA so you don't want to spend too much time in an off resonance condition. I suspect that the power transformer has more than enough capacity to cause a "meltdown" of the finals in an off resonance condition.



The E.F. Johnson Challenger sitting beside the Hallicrafters SX-100.

This article was written 10/93 and originally appeared in Electric Radio, Apr.'94, issue #60, "The E.F. Johnson Viking Challenger", pgs. 34-35.

Selected References:

1. "Recent Equipment - The Johnson Viking Challenger Transmitter", QST, Dec.'59, pgs. 46-47.

- - THE HEATH HG-10 VFO - -

My interest in the Heath HG-10 Remote VFO is fairly recent. I was measuring the warm-up characteristics of the Heath MR-1 and HR-20 receivers and the HX-20 and MT-1 transmitters and was pleasantly surprised how "good" they were. Since the HG-10 shares many design characteristics, I bought the first of three at the local TRW swapmeet and proceeded to evaluate its warm-up characteristics.

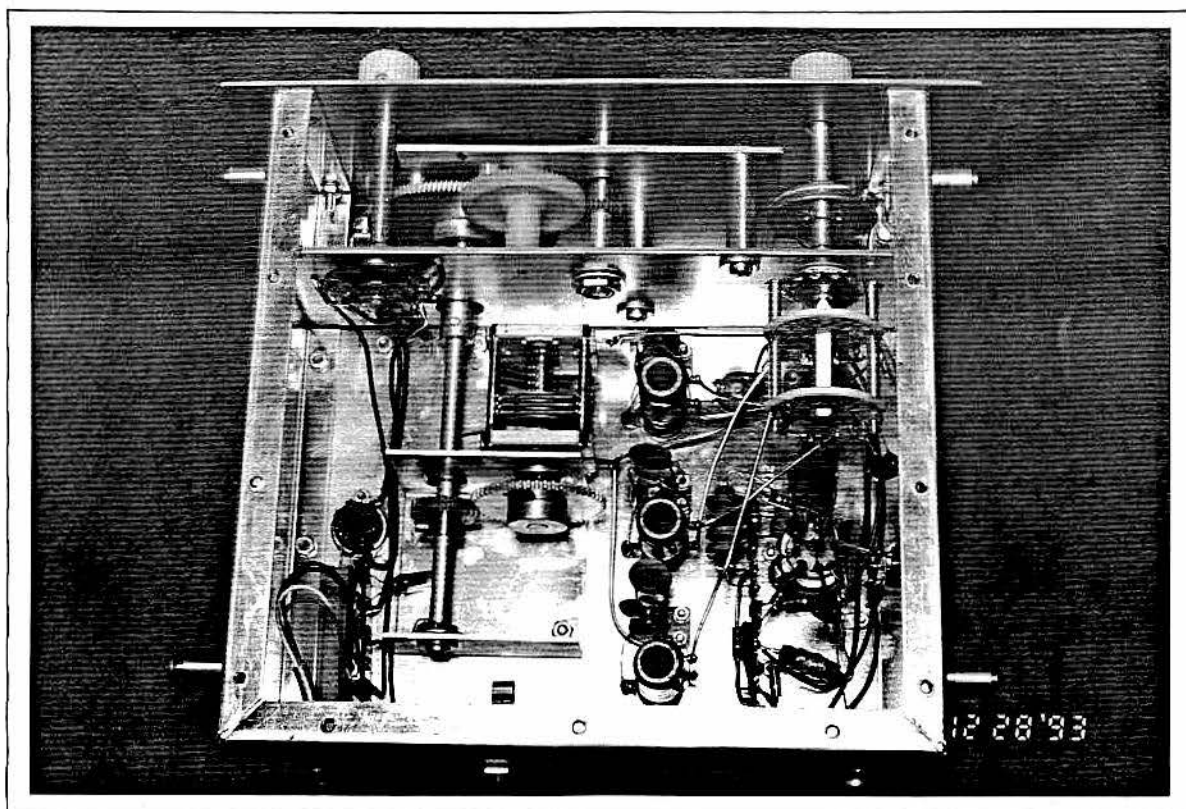


Front view of the Heath HG-10 VFO.

The Heath Model HG-10(B) is a seven band, 80 through 2 meters, remote VFO that was available from 1961 through (at least) 1973. It is designed with a rigid steel chassis that provides additional mechanical strength and stability over that of the older Heath Model VF-1 VFO. The HG-10(B) was available almost twice as long as the VF-1 and presumably, is more plentiful. The differences between the original HG-10 and later HG-10B are basically cosmetic.

A 6CH8 is used as a series-tuned Colpitts (Clapp) oscillator and a cathode follower. The oscillator uses an EF Johnson double-bearing ceramic tuning capacitor driven by a relatively complicated 28:1 gear drive vernier tuning system. The output frequency is indicated on a rotating drum dial - a separate dial scale provided for each band. The three separate inductors used in the frequency determining circuits are wound on ceramic forms and

epoxy coated. Each inductor is separately temperature compensated.



Under chassis view. Note the relatively complicated 28:1 gear drive vernier tuning system. The 10K 10W WW OB2 dropping resistor can be seen in the lower left-hand corner, below the OB2's 7-pin socket.

The 6CH8's plate supply is regulated at 108 VDC by an internal OB2 voltage regulator and an optional 10K 10W series dropping resistor. The HG-10 can be powered by the transmitter's accessory socket or a separate power supply such as the one described in the owner's manual can be used.

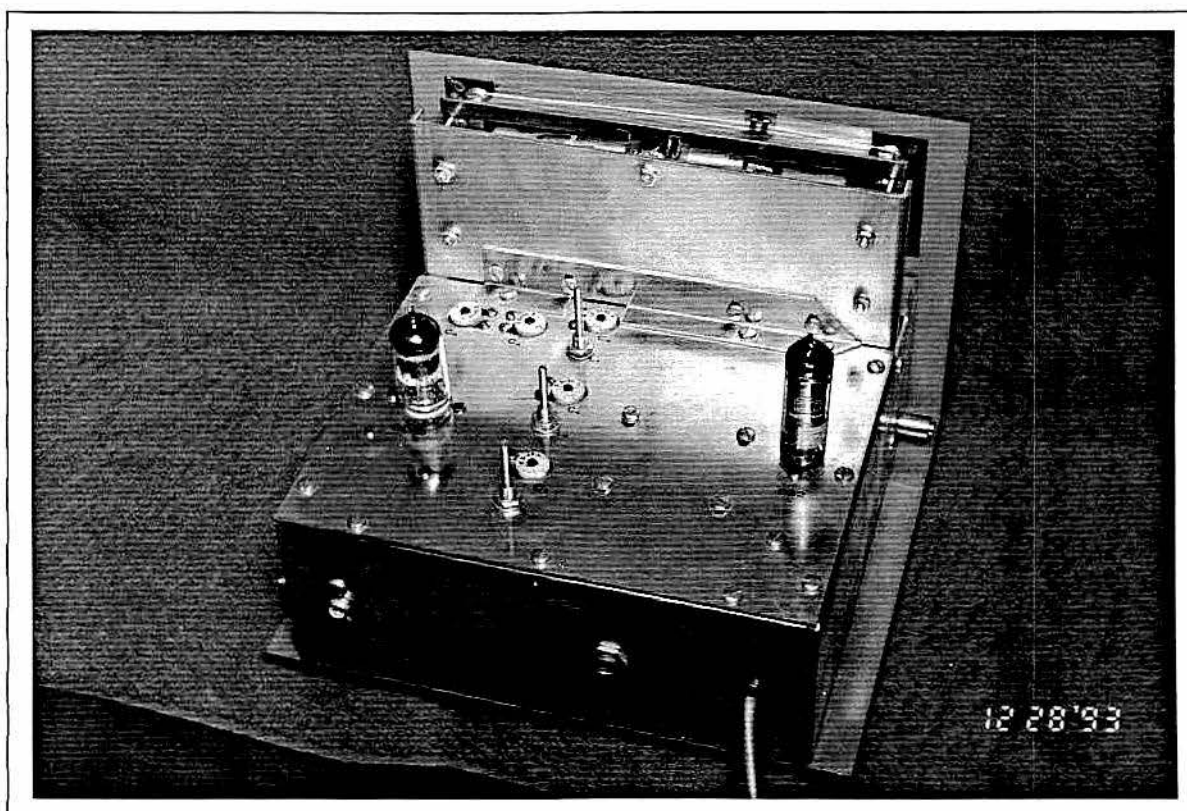
The HG-10 can be configured for either cathode (DX-40) or grid-block (DX-60) keying depending on the transmitter used.

When I first tested the HG-10, it drifted a maximum of -860 Hz during the first 75 minutes at 7.2500 MHz. After the first hour of operation, the drift averaged 120 Hz/hr. This was using the recommended 350 VDC external power supply using the internal 10K/10W dropping resistor and OB2 voltage regulator. This configuration dissipated 13.5W inside the HG-10. The 10K/10W resistor is mounted under the chassis and has to cause a "nasty" temperature gradient across the LC components. In addition, if you follow the HG-10 owner's manual, it is perfectly "legal" to install a 20K/20W resistor for R11 and power the HG-10 from an external 600 VDC supply for a total of 19.7W dissipated inside the



## HG-10!!

To minimize warm-up drift, you have to reduce the internal power dissipation as much as possible. To do this, I "removed" the 0B2 and 10K/10W from the HG-10 and installed them into an external power supply similar to the one recommended in the owner's manual. They could also be installed in the transmitter if you are powering the HG-10 from the transmitter. This relatively simple modification resulted in a 59% reduction in the power dissipated inside the HG-10, from 13.5W to 5.6W. More importantly, the HG-10 only drifted a maximum of -360 Hz during the first 90 minutes at 7.2500 MHz. After the first hour of operation, the drift averaged 45 Hz/hr for the next six hours.



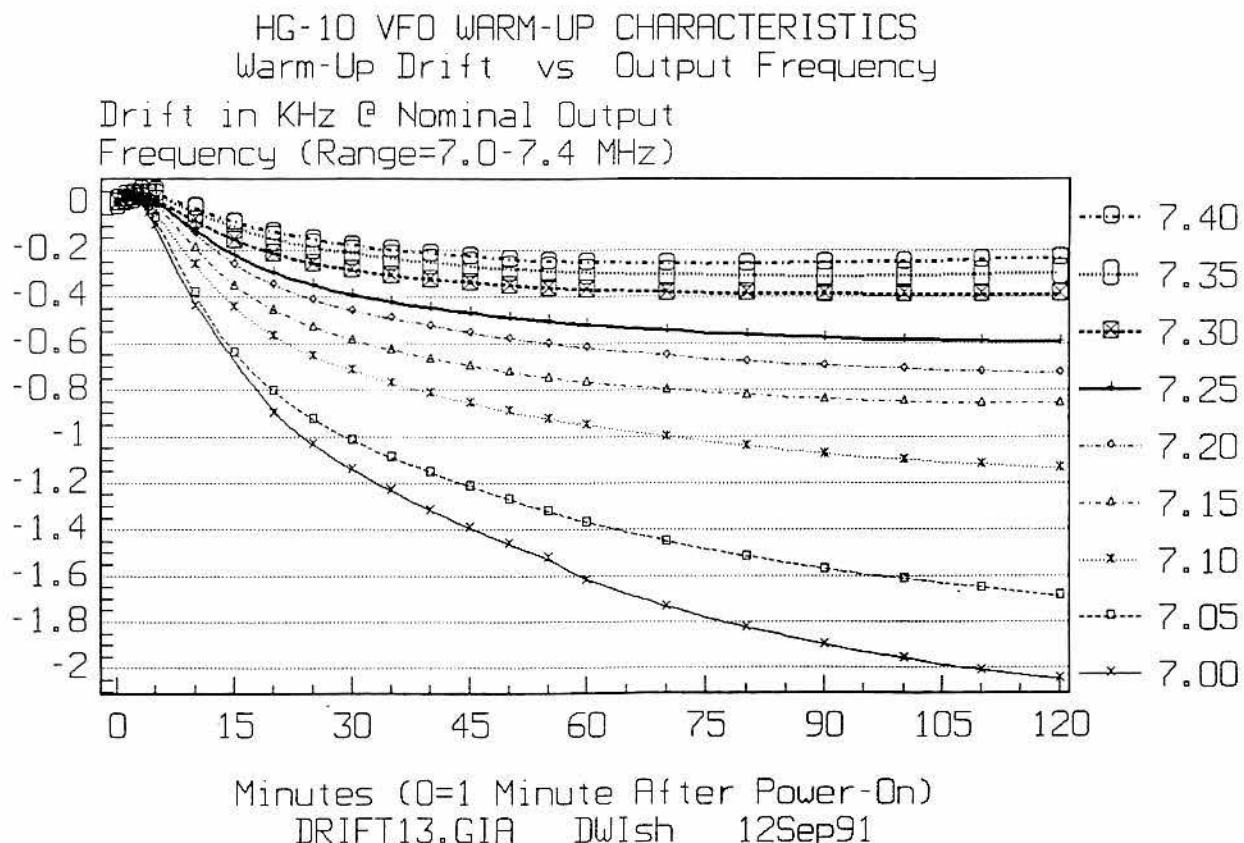
Rear view. The 6CH8 is to the left of the 0B2 voltage regulator.

One additional test that I did for "grins" was to remove the HG-10's cover and place a small room fan up against the rear of the chassis. The maximum warm-up drift at 7.2500 MHz was 55 Hz during the first 4 minutes of operation. After 10 minutes of operation, the HG-10 never drifted more than 56 Hz during the next two hours!! Now I admit that a small room fan is **NOT** a very practical addition to an HG-10! However, the test does illustrate the importance of getting the heat out - of reducing the HG-10's internal temperature rise. This test also opens up some possibilities in using (say) a muffin fan or equivalent to reduce the HG-10's internal temperature.



One caveat is worth mentioning. The HG-10 has four output frequencies: 3.5 - 4.0 MHz (80M), 7.0 - 7.425 MHz (40, 20, 15, & 10M), 8.333 - 9.0 MHz (6M), and 8.0 - 8.222 MHz (2M). Keep in mind that all my tests to this point were done at a single, arbitrary frequency of 7.2500 MHz. Don't be lulled into a "false sense of security" by only checking one frequency on your VFO. Walt Hutchens, KJ4KV, cautioned me about placing too much faith in the measured warm-up drift of receivers that were taken at a single frequency on a band. He went on to say that "results often vary substantially from one part of a band on a receiver to another". Well, the same is true for VFOs. Be sure to measure the VFO's warm-up drift at several points or at least where you expect to use it.

After I had minimized the warm-up drift at 7.2500 MHz, I measured the warm-up drift at 50 KHz intervals from 7.0 - 7.4 MHz. I ran each of the frequencies for two hours from a cold start. The resultant warm-up drift profile of my HG-10 is very interesting. At 7.4 MHz, the maximum drift was -250 Hz increasing to -2 KHz at 7.0 MHz. The temperature coefficient (tempco) of the VFO is more negative as the output frequency decreases and as the capacitance of the tuning capacitor increases. Two more HG-10s that I tested also exhibited frequency-dependent warm-up characteristics.



An article by T.A. Hunter, WONTI, **Permeability-Tuned Oscillators** in the August 1946 QST stated that the tuning capacitors in VFOs have a positive temperature coefficient of 10 - 40 ppm/°C. Positive tempcos in the variable will cause a negative tempco of the output frequency. When I run the drift profile across the HG-10's operating range, the only component I am changing is the variable and its' **tempco contribution** to the rest of the LC components. At first, I assumed that If the variable's tempco is relatively large, say approaching the 40 ppm mentioned in the WONTI article, then the overall VFO tempco is going to be relatively poor and temperature compensation will occur at only one spot on the dial. The HG-10's drift profile suggested that the tuning capacitor's tempco played a significant role in the HG-10's warm-up characteristics.

A few things have occurred since I originally ran the HG-10 warm-up tests that have changed my mind about the significance of the variable's tempco in the overall warm-up characteristics of the HG-10:

- \* Doug DeMaw/W1FB sent me an equation for determining the output frequency of a series-tuned Colpitts (Clapp) VFO from his QRP Notebook (pg.163). Plugging the HG-10's component values into the equation and assuming that the variable would drift 40ppm/°C resulted in calculated drifts significantly lower than those measured.

- \* I recently repackaged an HG-10 using most of the original HG-10 components, including the variable and the same compensation components. The measured warm-up drift of the repackaged HG-10 is not frequency dependent on either 80 or 40M. It uses a direct drive vernier dial instead of the original gear-train. It behaves significantly different than the three HG-10s that I have tested to date.

- \* There is one other thing that gets changed as a function of output frequency in the HG-10 - the large anti-backlash gear on the variable's shaft. If this gear, or the drive gear isn't concentric, the resultant change in force against the variable's shaft as a function of position/output frequency might change its tempco.

While not as "good" as my old Kenwood VFO-240, my HG-10 now drifts -300 Hz in 70 minutes at 7.2500 MHz. After one hour of operation, the drift averaged 45 Hz/hr for the next four hours. After 30 minutes of operation, the drift never exceeded 100 Hz/hr.

My Kenwood VFO-240 is the most stable VFO I have owned. 111 Hz maximum drift after 45 minutes and 22 Hz/hr average for the next 4 hours. It "stabilized" after four hours. This VFO uses a solid-state Clapp oscillator. The TS-530S' internal VFO was 234 Hz maximum drift after 55 minutes and 65 Hz/hr average for the next 4 hours. The TS-530S' VFO is burdened by the heat generated by the 6146s and 12BY7. That is why I used the remote VFO-240 - it was essentially rock solid.

It is worthwhile comparing the HG-10 to the performance of the

VFO-240 or TS-530S because I need a benchmark, a standard of comparison. I never think of these units as being "noticeably drift". As a result, if I can approach this level of drift with the HG-10 (or any other VFO) then I can probably be fairly confident that the drift is acceptable.

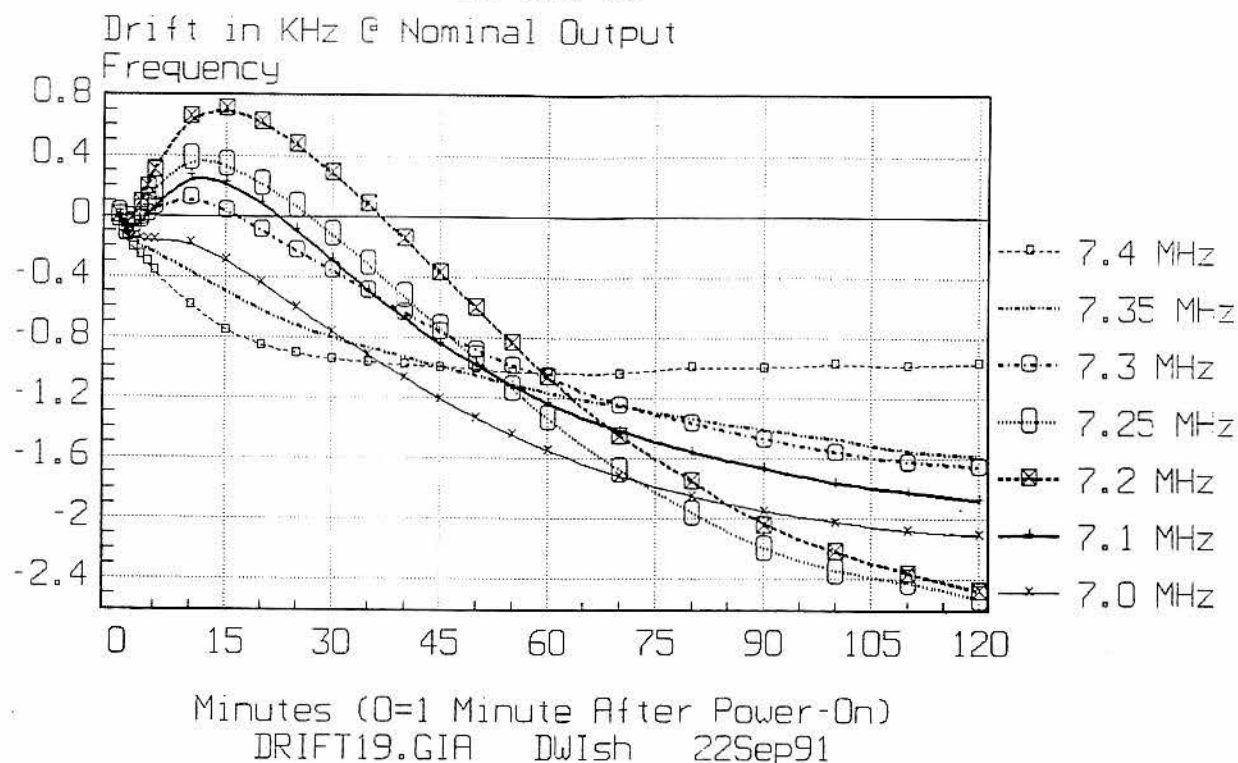
The Heath HG-10 is one of the best kit-type VFOs that I have played with to date in terms of the quality of the components and the mechanical construction.

This article was written 11/91.

#### Selected References:

1. "CQ Reviews: The Heathkit HG-10B V.F.O.", Wilfred M. Scherer, W2AEF, CQ Magazine, Mar.'70, pgs. 29-31, 92.
2. "Recent Equipment - Heathkit Model HG-10 V.F.O.", QST, Oct.'63, pgs. 54-55.

#### HG-10B VFO WARM-UP DRIFT CHARACTERISTICS HG-10B #2



This is the warm-up characteristics of a second Heath HG-10B. Compare this warm-up profile to the one on pg.105. The warm-up characteristics of three HG-10(B)'s were all different and all somewhat frequency dependent. Compare these two graphs to the warm-up characteristics of the Recycled HG-10 on pg. 113.

As I pointed out in the last paragraph of my article on building a two-tube 6AG7/6E5 80/40M CW xmtr (ER#56), "crystal control.....is NOT what it used to be". Xtal control is OK but what's really frustrating is calling CQ and then finding another CQ being sent within a few KHz of my xtal frequency with no way to call them. I find that this happens a lot. As a result of those frustrations, I started looking into building a matching VFO for my QRP xmtr.

Walt Hutchens/KJ4KV's article, "A Not Noticeably Drifty VFO" (ER#32 & 33) will probably serve as a "benchmark", the piece de resistance, for VFO construction articles. It was very well written and contained an immense amount of technical information not usually found in "how to build VFO" articles. The technical information was well blended with the construction portion of the article. Walt's article is "must reading" for anyone even thinking about playing with VFO design and/or temperature compensation.



Front view of the recycled HG-10 VFO with 6AG7/6E5 80/40M QRP xmtr and recycled HK-5A keyer.

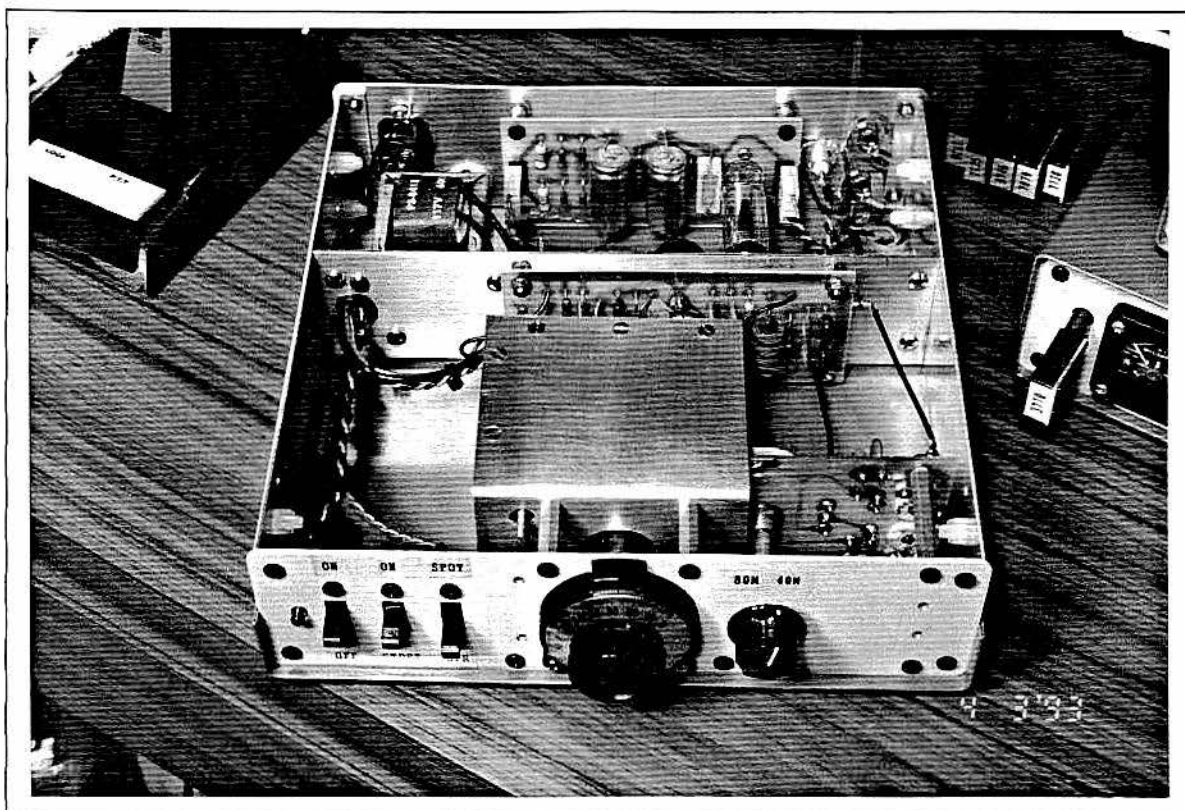
I decided, however, not to follow in Walt's footsteps. Why??? Because there are dozens, perhaps hundreds, of old Heath VF-1s and HG-10/10Bs, Johnson 122s, Knights, EICO 722s, and other vintage VFOs that are in poor shape, have little collector value, and



are "rusting away" in someone's garage. These vintage VFOs are an excellent source for the LC oscillator components. Most of these VFOs used a Clapp oscillator. So in spite of Walt's warning about the Clapp oscillator (ER#32,pg.6), I proceeded to repackage one.

I chose to rebuild/recycle/repackage the Heath HG-10 for a number of reasons:

- \* I have spent a lot of time evaluating the warm-up characteristics of three HG-10s. While still "noticeably drift", they are better than many vintage (Clapp) VFOs I have tested.
- \* The HG-10 uses a cathode follower for isolation between the oscillator and output/transmitter input.
- \* The HG-10 cathode-keys pretty well on 80/40M.
- \* Dave Anderson/WA6BWW had given me a cannibalized HG-10 and it still had all the 80/40M LC components.



Top front view. The LC, 6CH8, and power supply PCB's are visible. A rigid 2-piece semi-box shield surrounds the LC components.

The following are some of the features of the recycled Heath HG-10:

- \* The schematic is almost identical to the original. Only the 80/40M components were used with a 2-pole 2-position ceramic rotary switch and the optional grid-block keying circuitry was eliminated.

- \* Even though I couldn't salvage the compensating caps from the HG-10 and in spite of the huge differences in packaging, I decided

to keep the NPO/N750 compensating caps the same value/ratio. I have made no effort to improve this VFO's tempco.

- \* Three circuit boards were used to simplify the construction - one for the "front-end"/LC components, one for the 6CH8 osc/buffer, and one for the power supply. The PCBs were made from GC Electronics pre-sensitized positive acting single-sided board material. They were laid out 1:1 on a quad-pad, taped on clear vinyl sheet protectors, and the artworks used to expose the boards. The boards were cut to size with a shear.

- \* The power supply is similar to the one described in the HG-10 manual but uses a bridge rectifier and is designed for absolute minimum power dissipation. The Stancor PS-8415 xfmr (125 VAC @ 15 ma and 6.3 VAC @ 0.6A) only runs a bit warm. An OB2 VR tube is used to regulate the oscillator's voltage at +108 VDC - same as the original. Keep in mind that the additional thermal load from the power supply will worsen the VFO's warm-up characteristics. If you want to minimize warm-up effects, you may want to consider **NOT** building the VFO's power supply into the VFO.

- \* The recycled HG-10 calibrates the same as the original and can be calibrated through the front panel with both covers on.

- \* A rigid 2-piece semi-box shield surrounds the LC components. The shield and LC PCB are mounted to the front panel w/6-32 hex standoffs.

- \* A 2" 0-100 vernier dial with 4-1/2:1 reduction drives the HG-10's E.F.Johnson double-bearing ceramic tuning capacitor (the original HG-10 uses a relatively complicated 28:1 gear drive vernier tuning system).

- \* The two inductors used in the frequency determining circuits are wound on ceramic forms and epoxy coated. Each inductor is separately temperature compensated.

So what do you get when you repackage a "noticeably drift" Heath HG-10 VFO? A repackaged "noticeably drift" VFO!

I selected the same enclosure that I used for my 2-tube 6AG7/6E5 xmtr, a Ten Tec CONSTRUCTO SERIES 2-1/2" x 9" x 9" BU929. Mechanical construction is similar to the 6AG7/6E5 xmtr.

As might be expected, the performance of the recycled HG-10 is very similar to the original. I did, however, have a few problems to contend with:

- \* The VFO output had quite a bit more harmonic content than the original and a 5 pF disk cap from the oscillator plate (pin 2) to ground quickly solved that "problem". I suspect that this was due to the differences in packaging and layout.

- \* The VFO output would jump in frequency occasionally. It turned out that in minimizing the OB2 current, I ran too little current through it at low-lines when the xmtr was keyed. The OB2 would extinguish, raising the 6CH8's plate voltage and changing the VFO frequency. I just increased the nominal OB2 current a bit and the frequency-shift problem was solved.

- \* The mechanical stability of the finished VFO was totally unacceptable!

I originally designed this VFO without an internal shield for the LC components - I hoped that the Ten Tec enclosure was mechanically rigid enough. **WRONG!** Not even close! The mechanical stability of the finished VFO was so bad that it gave the term "microphonics" a new meaning, especially on 40M. Adding the VFO's top cover shifted the output frequency 70-80KHz on 40M, about 1%. More importantly, **any movement of the top cover caused unacceptable shifts in frequency.** A bump to my operating bench eight feet from the VFO would cause an unacceptable frequency shift. After discussing the situation with Hal Keeling/N6ECY over several cups of coffee, he recommended an additional internal shield around the LC components. The problem was, I didn't design the PCB/front panel layout to accommodate an internal shield.

I removed the LC circuit board and "shaved" about 0.06" off the top and bottom edges - just enough to clear the additional shield. I then added a U-shaped aluminum shield around the LC circuit board but it was only about 80% effective - still not acceptable. Interestingly enough, the frequency shift caused by the addition of the aluminum shield appeared to be a capacitive effect only. After adjusting out the offset, the VFO's tracking was unaffected.

More discussions.....I removed the U-shaped shield and gave it to Sid Hood/KD6NIM, who fabricated an additional L-shaped shield section to fit inside the U-shaped section. This was a bit "dicey" dimensionally because the BU929's covers still had to fit over the added internal shield(s) - there was essentially zero-clearance between the covers and the outside of the U-shaped shield. Sid's L-shaped section was a perfect fit! Adding the L-shaped section to the U-shaped shield created a semi-box shield that was about +99% effective. The L-shaped section was attached to U-shaped shield with ten 4-40 x 1/8" countersunk screws. Now I could lightly tap on the outside covers with a small hammer with no effect on the VFO's signal!

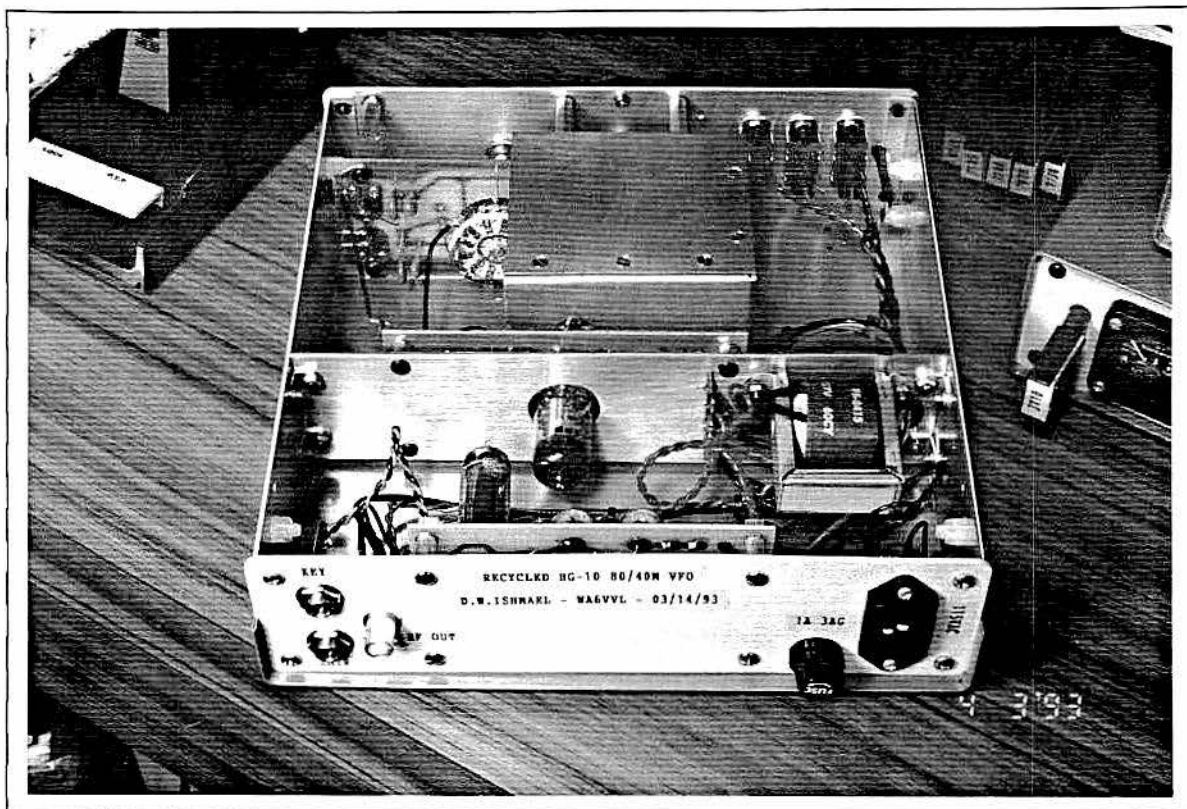
If I seemed overly enthusiastic over the Ten Tec CONSTRUCTO SERIES enclosure in my 2-tube 6AG7/6E5 article, I am even more so now. I had to take this VFO apart a dozen or so times in experimenting with and retrofitting the LC shield(s). The modular construction of the BU929 enclosure made the experimenting/retrofitting much less painful!

The total time for construction was 47 hours which included preliminary checkout, calibration, and retrofitting the shields. The total cost was \$75 which includes \$37 for the Ten Tec BU929 cabinet and \$14 for the vernier tuning knob.

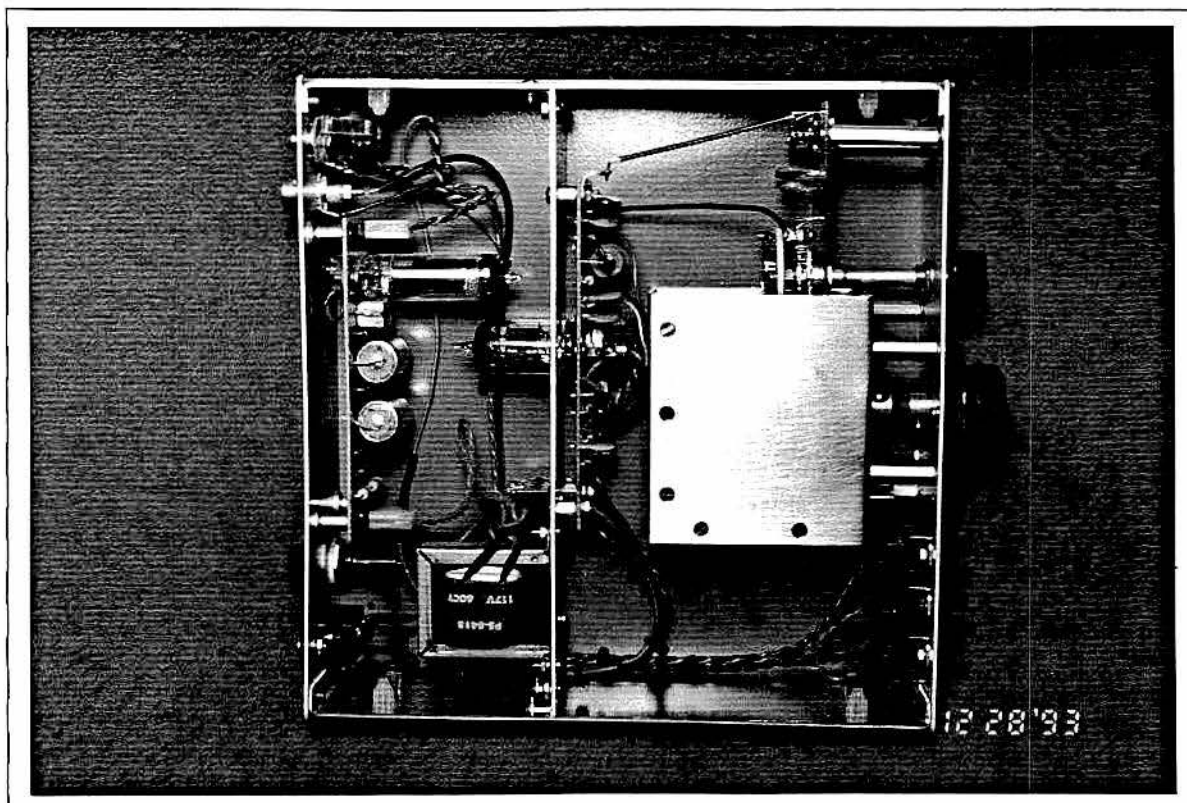
After the mechanical stability problems were solved, I spent a couple of weeks evaluating the VFO's warm-up characteristics:

- \* On 80M, the VFO drifted a maximum of -410 Hz during the first 70 minutes of operation from a cold-start. After 70 minutes, the VFO drifted an average of +75 Hz/hour for the next four hours.
- \* On 40M, the VFO drifted a maximum of -3.25 KHz during the





Top rear view.



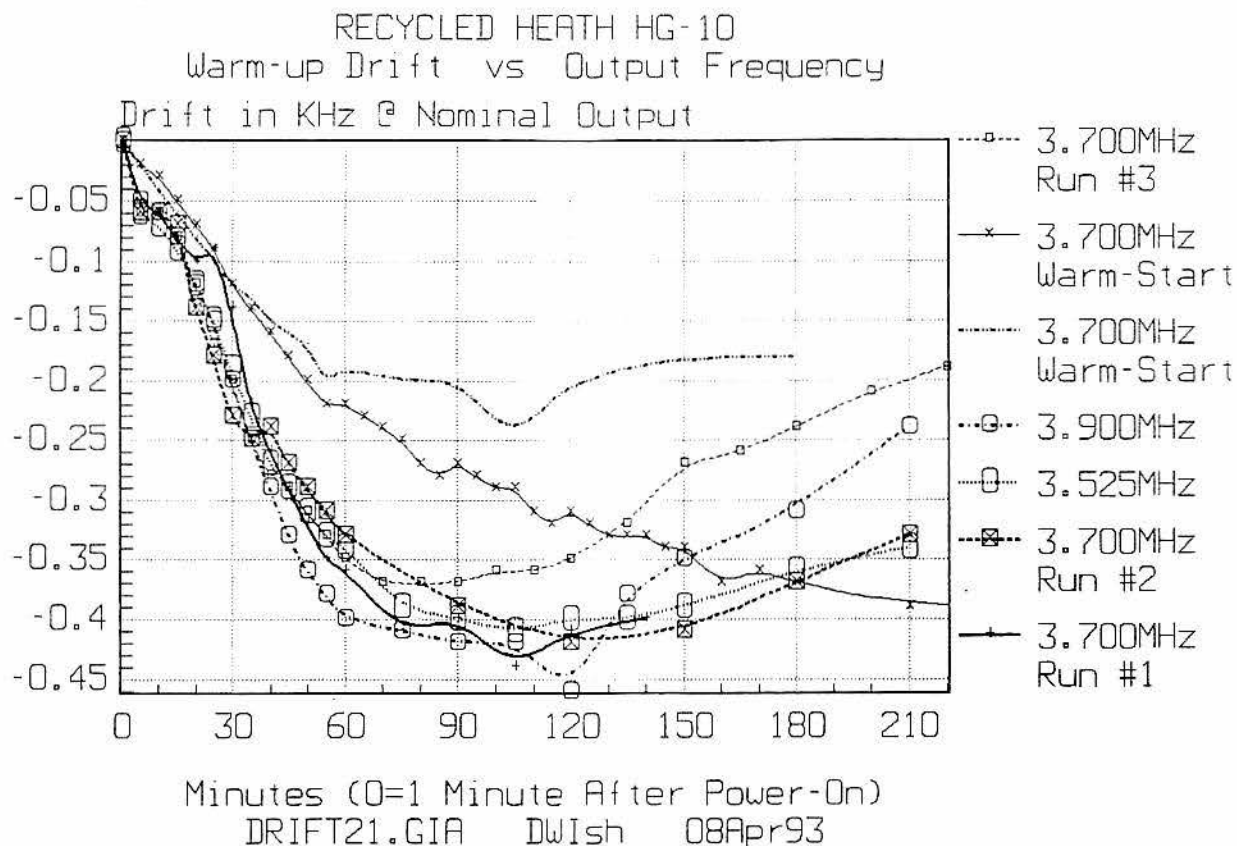
Top view.



first 70 minutes of operation from a cold-start. After 70 minutes, the VFO drifted an average of 100 Hz/hour for the next two hours.

\* The warm-up characteristics from a cold-start appear to be pretty independent of frequency. This is in contrast to three HG-10s that exhibited warm-up characteristics that were very dependent on frequency.

\* The warm-up characteristics from a warm-start, the VFO left in STANDBY overnight, didn't buy much in terms of improved Hz/hour stability. Even though the warm-up characteristics from a warm-start were significantly different from those from a coldstart, the Hz/hour stabilities were comparable.



Building this VFO was a "sobering" experience. I thought that I had a pretty good "handle" on VFO design before I started this project. I have built two previous, relatively successful, Clapp oscillator VFOs using open chassis construction with few problems, mechanical or otherwise. This was the tightest package I have attempted to build and I was totally unprepared for the magnitude of the mechanical stability problems that I encountered. Luckily, the retrofitted semi-box shield worked very well and had little impact on my original front panel and LC PCB designs. I learned a great deal more about VFO design than I had bargained for.

I believe the original premise of building this VFO is sound. You CAN successfully build/repackage a VFO using a vintage VFO "parts

unit" as a source for the LC components. However, don't expect the "noticeably drifty" warm-up characteristics of the original VFO to significantly improve. In fact, by altering the thermal characteristics of the original design (e.g., adding an internal power supply), you can make it worse.

This article was written 4/93.

#### Selected References:

1. "Permeability-Tuned Oscillators", T.A. Hunter, WONTI, QST, Aug.'46, pgs. 43-46.
2. "An Inductance-Capacity Oscillator of Unusual Frequency Stability", J.K.Clapp, Proc.I.R.E., Mar.'48.
3. "A High-Stability Oscillator Circuit", Technical Topics, QST, May '48, pgs. 42-43.
4. "The Clapp High-Stability Circuit", Technical Topics, QST, Oct.'48, pgs. 45-47.
5. "Some Notes on the Clapp Oscillator", Richard G. Talpey, W2PUD, QST, Jan.'49, pgs. 45,48.
6. "Tailoring the Series Tuned VFO to Your Needs", G.L. Countryman, W1RBK, QST, Oct.'49, pgs. 42-45, 100.
7. "Adjustable Tuning Rate for VFOs", Hints and Kinks, QST, Jan.'50, pg. 46.
8. "Cutting Down VFO Drift", Richard E. Long, W3ASW, QST, Aug.'52, pgs. 21-22, 114.
9. "The Clapp Oscillator - and How", Rex Cassey, ZL2IQ, QST, Feb.'53, pgs. 19-21, 122.
10. "Bandspreading the Clapp VFO", O.J.Russell, G3BHJ, QST, Oct.'54, pg. 37.
11. "An Ultrastable Keyed V.F.O.", J.M.Shulman, W6EBY, QST, Oct.'57, pgs. 34-39.
12. "Let's Increase V.F.O. Stability", W.B.Bernard, W4ELZ, QST, Oct.'57, pgs. 40-42.
13. "Designing the VFO", Louis Howson, W2YKY, QST, Dec.'55, pgs. 35-39, 166, 168, 170.
14. "V.F.O. Stability - Recap and Postscript - Part I", George Grammer, W1DF, QST, Sep.'66, pgs. 22-27, 154.
15. "V.F.O. Stability - Recap and Postscript - Part II", George Grammer, W1DF, QST, Oct.'66, pgs. 26-32.
16. "A Not Noticeably Drifty VFO - Part I - Theory, Results, and Causes of Drift", Walt Hutchens, KJ4KV, Electric Radio, Dec.'91, issue #32, pgs. 4-9.
17. "A Not Noticeably Drifty VFO - Part II - Construction", Walt Hutchens, KJ4KV, Electric Radio, Jan.'92, issue #33, pgs. 4-9, 30.

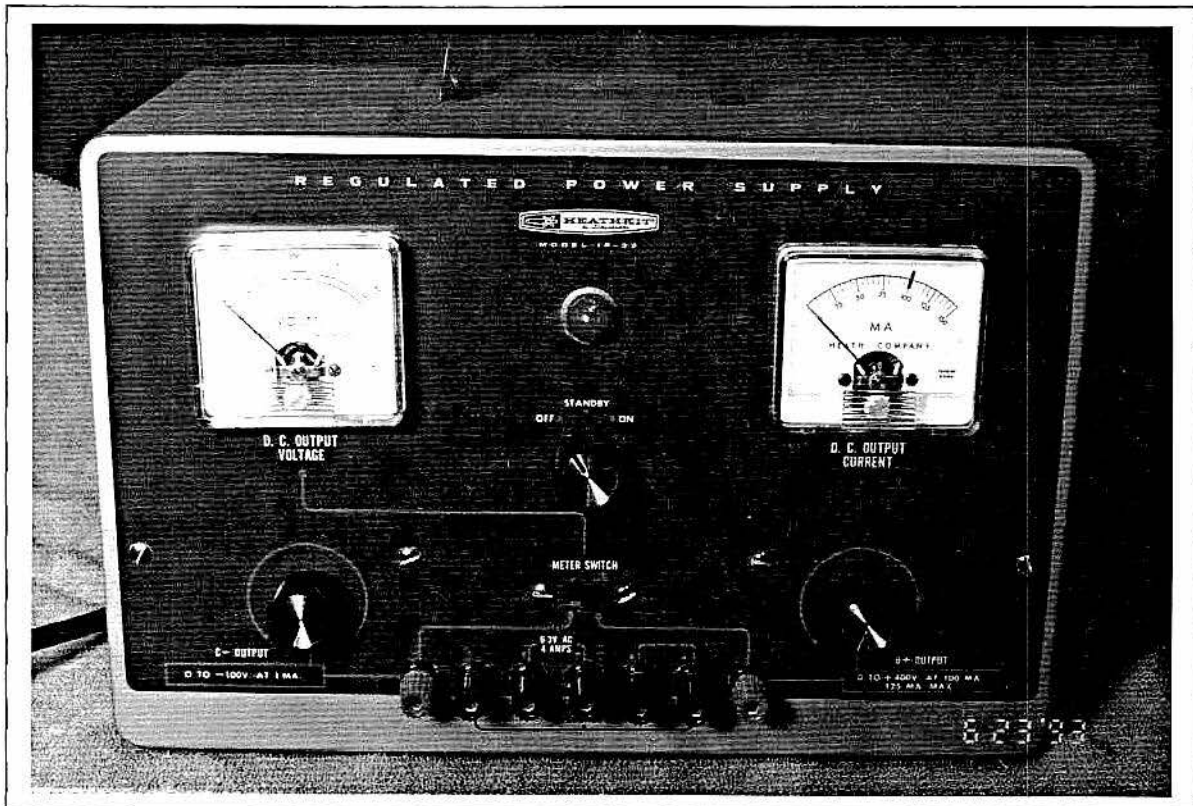
Note: Not all of these articles are Clapp specific (e.g., WONTI's article on permeability-tuned oscillators). However, they do have something to offer the VFO builder....

## 18DEC93



- - - HEATH IP-32 POWER SUPPLY - - -  
- Real Power Supplies Glow in the Dark -

If you do even a modest amount of work with vacuum tubes, a variable DC regulated power supply can be a valuable addition to your shack. My Heath IP-32 & IP-17 are the most often used pieces of test equipment in my shack. They can be used for reforming electrolytics, powering breadboards, testing meters, power supplies for projects built without them, troubleshooting low power xmtrs and rcvrs,..... The list is endless.



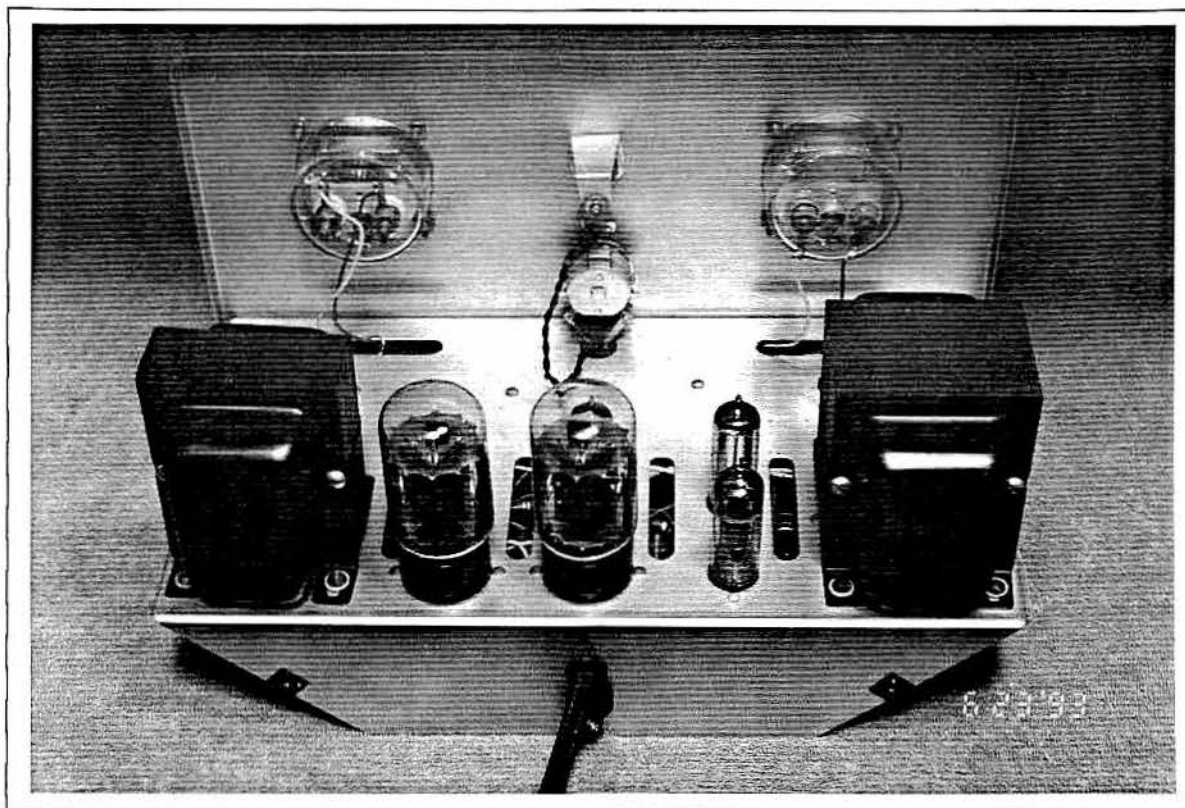
Front view of the Heath IP-32 Power Supply. Meters monitor current and voltage simultaneously in the 0-400V position.

I purchased my 1st IP-32 at a computer swapmeet for \$5. The 2nd and 3rd were purchased at the TRW swapmeet for \$10 each. I have seen quite a few IP-32s at TRW in the \$10-20 range. The IP-17, while more desirable (it is smaller and has an additional 12.6VAC at 2A output), is a bit rare. When they do show up, the asking prices are pretty high, >\$75 in some cases. An exception were three SP-17s at the 7/93 Rio Hondo swapmeet for \$20 each.

The IP-32 sold for \$56.95 in '62-'63. It is a 6-tube DC regulated power supply that provides 0-400VDC at 100mA continuous (125mA intermittent), 0 to -100VDC at 1mA, and 6.3VAC at 4A. The DC outputs are fully metered with 0-150VDC or 0-400VDC and 0-150mA 2-1/2" meters. The IP-32 is an improved 2nd generation PS-4. The



3rd generation IP-17, basically a repackaged IP-32, was introduced in the new beige low profile instrument case. IP-17 variants include the SP-17A and SP-2717A.



Rear view. Dual-6L6GB regulator tubes.

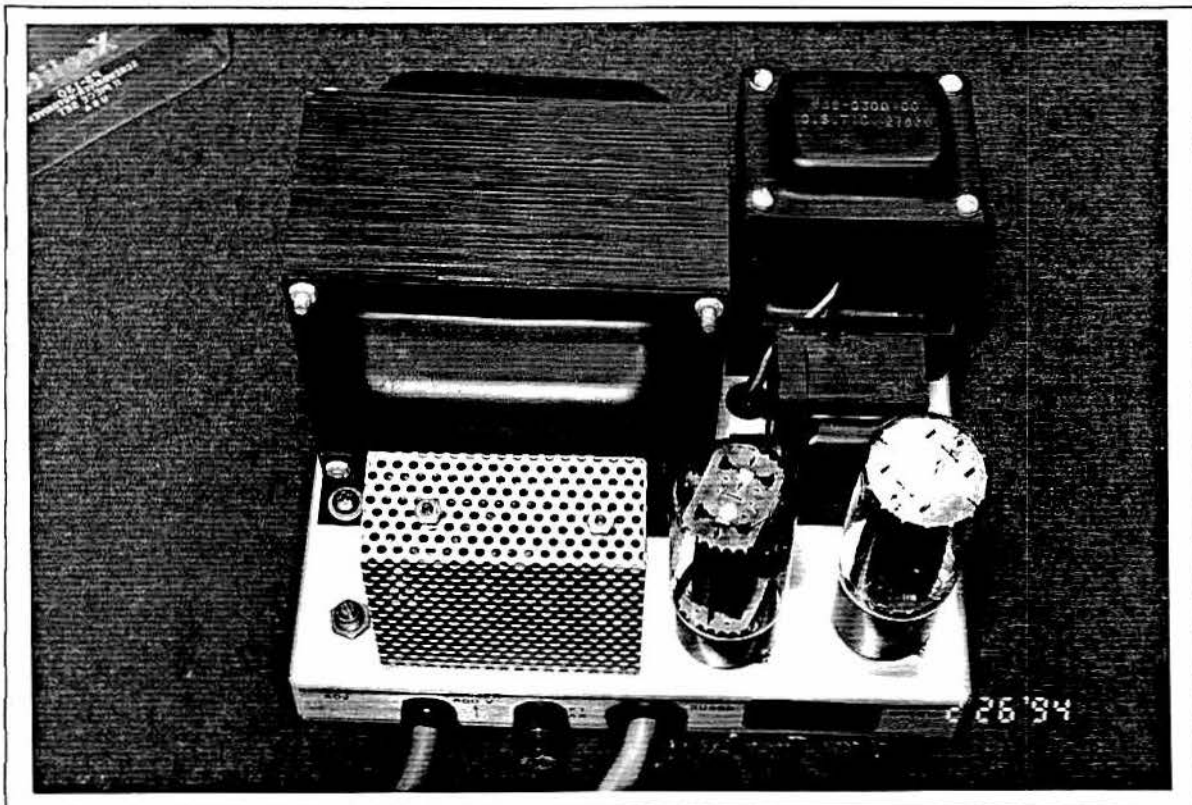
Once you start using these supplies, you're going to wonder how you got along for so long without one.

This article was written 7/93 and originally appeared in Electric Radio, Aug.'93, issue #52, "The Heath IP-32, Real Power Supplies Glow in the Dark", pgs. 26-27.

#### Selected References:

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2. "Combination Regulated Power Supply", L.D. Chapman, W4PRM, QST, Oct.'57, pgs. 16-17.
3. "Improved Control Circuit for Regulated Power Supplies", George W. Jones, W1PLJ, QST, Nov.'57, pgs. 30-33.
4. "A Multioutput Variable-Voltage Power Supply", Howard Cohen, K2ITO, QST, Aug.'61, pgs. 27-28, 152.
5. "A Utility Power Supply Made From An Old TV Set", Lewis G. McCoy, W1ICP, QST, Sep.'61, pgs. 38-41.
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7. "A general-Purpose Voltage-Regulated Power Supply", John "Dutch" Nydam, WA6JCZ, QST, Mar.'66, pgs. 22-24.

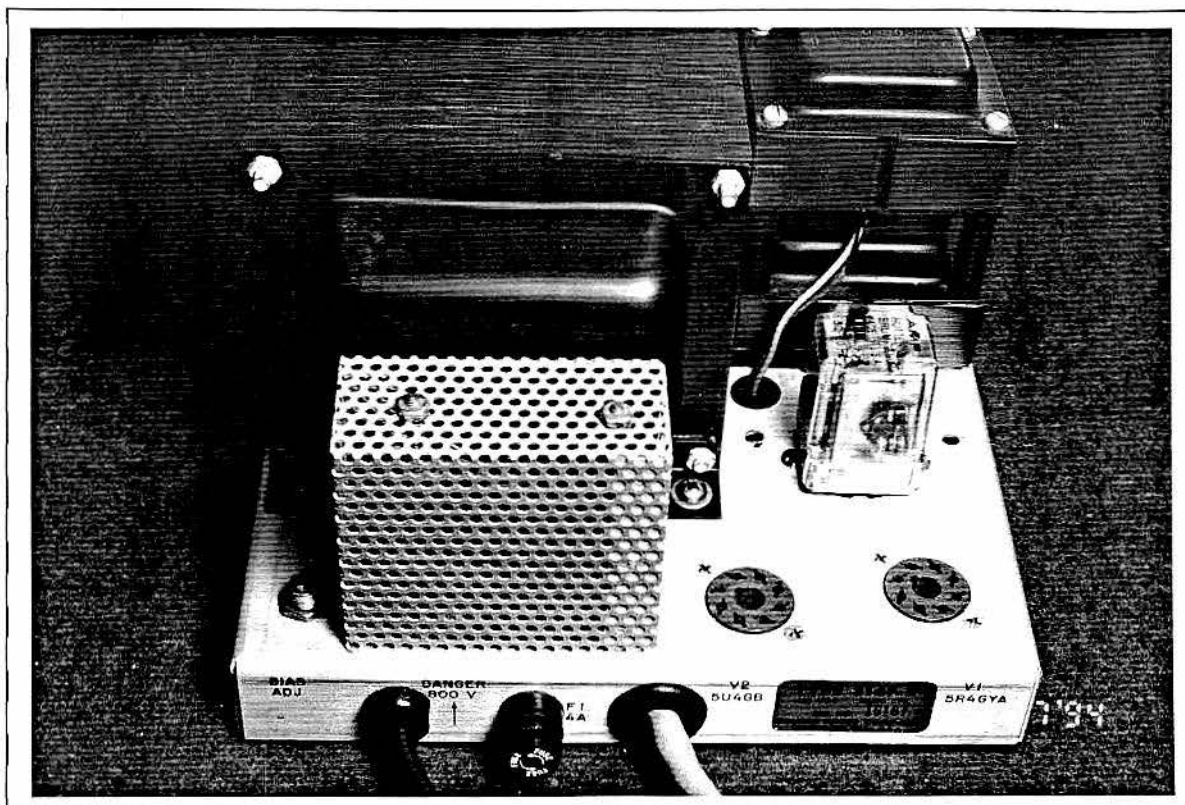
While "hanging out" at Dave Kamlin's (AB6XK) WIRELESS WORLD in Laguna Niguel, CA, he introduced me to a very interesting and worthwhile Collins 516F-2 power supply mod - the addition of a 120VAC relay to eliminate the high inrush currents on the 32S-? or KWM-2/2A on/off switch. While it is true that the HV secondaries are effectively open during power-on using the 5U4 and 5R4, the real culprit is the worst-case inrush currents during the initial magnetization of the xfmr's core. This worst-case power-on condition occurs when power-on coincides with the peak AC line voltage. These currents are especially high with relatively low DC resistances in the xfmr's primary winding - like the 516F-2's xfmr. Fortunately, this happens relatively infrequently. When it does however, these inrush currents can be pretty high and can lead to the premature failure of the on/off switch's contacts - welding the contacts in the "on" or closed position. It's not a switch problem per se, it's a design problem. These switches have a reputation for failing.



Top rear view of an unmodified Collins 516F-2 power supply. The LV choke, L3, is directly behind the 5U4 & 5R4 rectifier tubes.

This mod has apparently been around for some time and will be "old news" to some ER readers.

A 120VAC DPDT octal-type relay is added to T1's primary circuit. The relay's contacts switch T1's primary while the 32S-? or KWM-2/2A on/off switch switches only the relay's coil current, 2.2VA. There are several sources for this relay: Potter & Brumfield, Guardian, Magnecraft, Deltrol, ..... and are available with either 5A or 10A contacts. Make sure you use the 10A relays w/silver-cad contacts. The 5A silver contacts are not "weld resistant" and may stick. Most of the relays have an optional neon indicator lamp wired in parallel with the coil.



Top rear view of the Collins 516F-2 power supply. L3 has been removed and replaced with a P&B KRP11AN DPDT octal-style relay.

My version of this mod follows:

- \* Now that the unit is upside down, check the condition of the line cord and remove and replace as required. Make sure the new cord's O.D. is the same as the old or the strain relief will be too loose/tight. I used a standard black 3-conductor 14 AWG line cord to replace the original Collins cord. Leave the white lead long enough to connect to pins 7 and 8 of the added octal socket.
- \* Remove L3. Cut L3's black and red leads at the terminal strip leaving pigtailed long enough to short together. Solder the pigtailed together. This will parallel C5A and C5B. Save L3 as you may wish to restore the 516F-2 to its original electrical condition someday.
- \* Remove C1 (0.05 ufd 1KV) and set aside.
- \* Locate and punch a 1" or 1-1/8" hole for an octal socket that

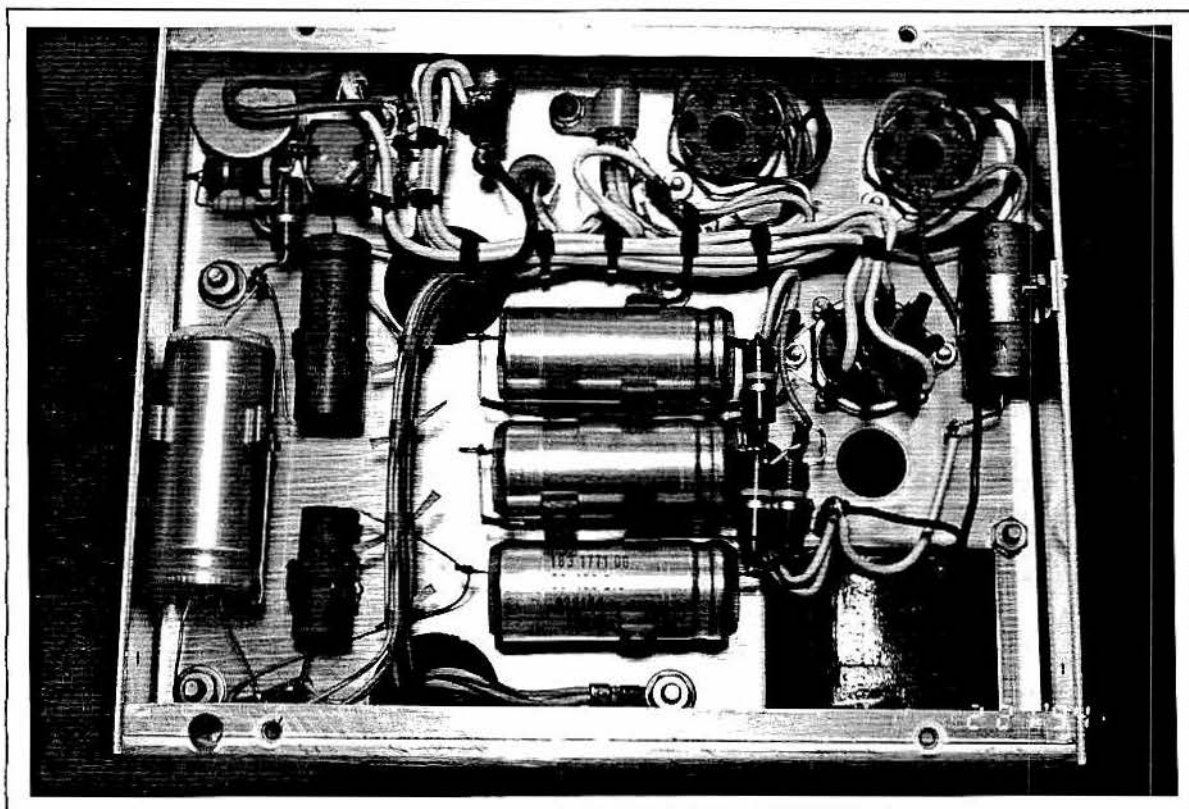


is approximately 1.7" from the side and 3.2" from the rear behind V1 & V2. This puts the socket in-line with the existing hole for L3. Using the octal socket as a guide to locate the mtg. holes, drill two additional #6 holes. Be very careful of the wiring harness when drilling the mtg. holes. Install the octal socket with the key-way toward the filter caps.

- \* Locate C1 against the side of the chassis close to V1 and drill a #6 hole for C1's bracket.

- \* Install C1 and connect across L1 (standoff near L1 & V1-pin 8).

- \* Wire the octal socket per the schematic. The wiring harness will have to be opened a bit to re-route the primary circuitry. Use tie-wraps to clean up the harness after the wiring has been completed.



Under chassis view of the modified Collins 516F-2 pwr supply. C1 has been relocated against the side of the chassis.

- \* Using heat-shrink tubing over the eight octal socket pins is not required but is highly recommended.

- \* Be very careful when drilling the pilot-hole for the chassis punch and the mounting holes for the octal socket and C1's bracket that ALL drill chips, burrs, filings, etc. are cleaned-up prior to powering up the 516F-2. Voltages > 800 VDC are present and it doesn't take but a very small aluminum sliver or burr to cause a short-circuit. You may want to remove the ventilated cover over R4-R6 and verify that this area is free of debris.



Now is also the time to change/trim the bias supplies' resistive divider (R8 and/or R10) to obtain the correct resting plate current for the 32S-? or KWM-2/2A. If the resting plate current is > 40 mA, the nominal bias voltage is too low, trim R8. If the resting plate current is < 40 mA, the nominal bias voltage is too high, trim R10.

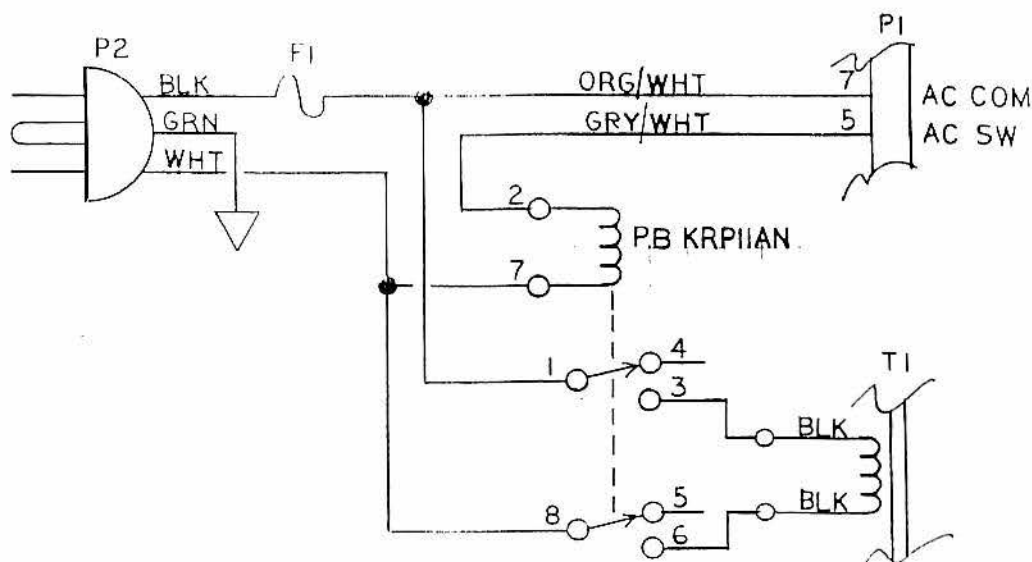
This mod took me about 3 hours and cost about \$1, thanks to the TRW swapmeet. I used a Potter-Brumfield KRP11AN relay. The wiring changes were very straightforward. The LV supply in my modified (less L3) 516F-2 is +288V @ 115VAC line in my KWM-2. L3 can be retained by mounting it above the KRP11AN relay on 10-32 hex standoffs. There was so little difference with L3, in or out, that I just left it out.

Incidentally, Collins recommended solid-stating the 516F-2 to cure the arc-over problem (and associated fuse blowing) with the 5U4 and 5R4 rectifiers (reference Service Information Letter 1-76). The first time I experienced this problem, I had my face buried in the rear of my 516F-2 - the arc-over scared the ~~&^!&%&~~ out of me. The Collins mod replaced the 5U4 and 5R4 rectifiers with Semtech SCH-5000 solid state diodes (CPN 353-0425-010). This change increases the HV and LV supplies approximately 12% - to +308V and +896V. Not wanting to solid-state my 516F-2, I selected 5U4's and 5R4's that didn't arc-over - end of problem. On the plus side, solid-stating the 516F-2 removes 25W of filament power from the xfmr's secondary - not too shabby.

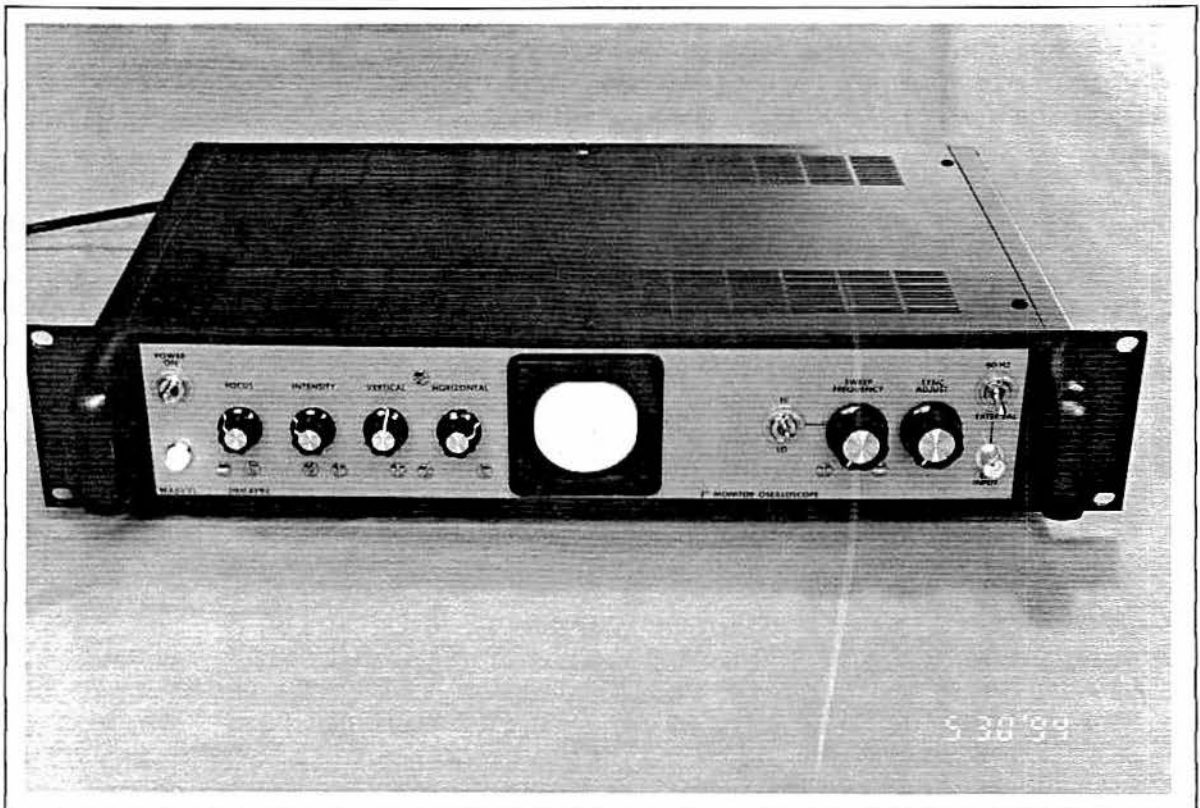
This article was written 2/94 and originally appeared in Electric Radio, June '94, issue #62, "Collins 516F-2 Power Supply Relay Mod", pgs. 24-25, 38.

#### Selected References:

1. "Collins 516F-2 Relay Modification - Revisited", Steve Thomason, WB4IJN, Electric Radio, Aug.'94, issue #64, pgs. 32 and 38.



- - - 2AP1A 2" MONITOR SCOPE - - -



Front view of the 2AP1A 2" Monitor Scope.

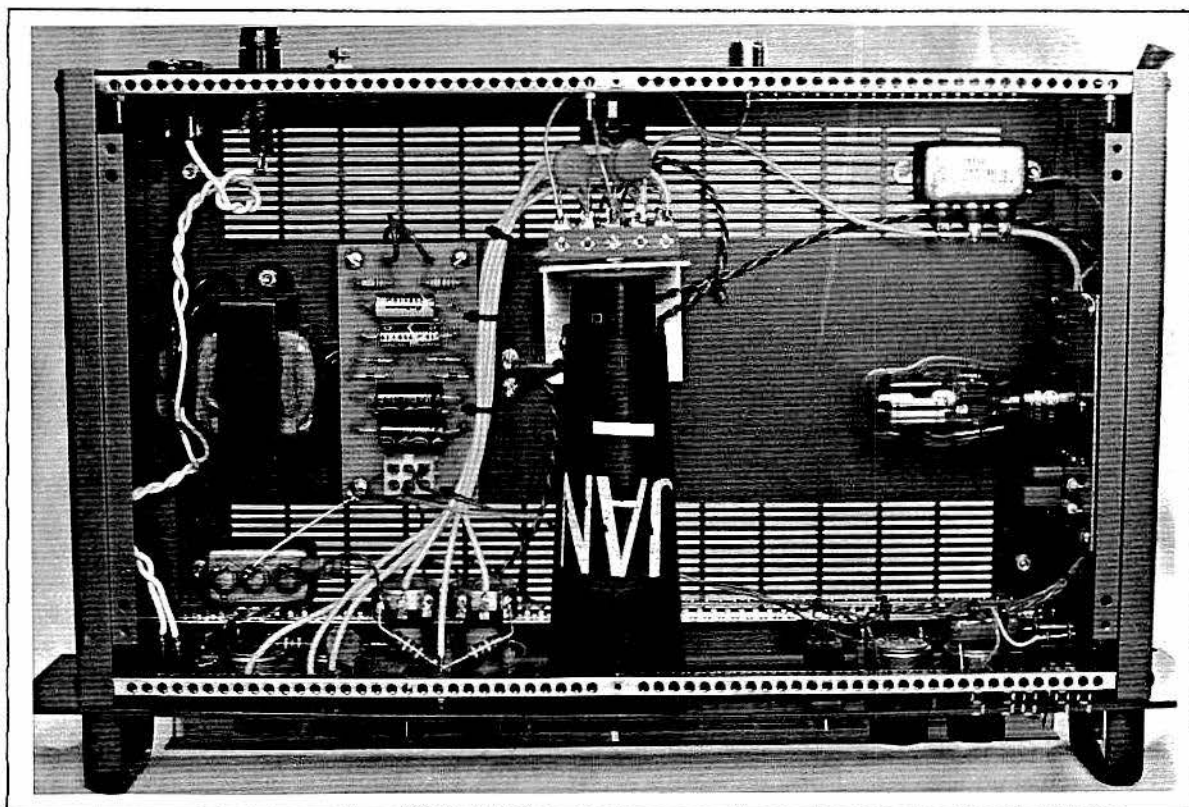
My "love affair" with oscilloscopes started about the same time I became interested in "radio". The owner of a Radio-TV repair shop in downtown Laguna Beach, CA., pulled a 2AP1 out of a piece of WWII surplus equipment and gave it to me during the summer of '58. It was two more years before I used it to build my first homebrew oscilloscope - right out of the pages of the ARRL Handbook(s). I can remember how excited I was as I unpacked the Millen 80072 2" bezel and the blue coil of push-back hook-up wire that I ordered from Allied Radio to build it. That first scope was built using a 12" x 7" x 3" aluminum chassis base as an enclosure and later rebuilt on a 5-1/4" x 19" black-wrinkle rack panel. The rebuilt scope used an 884 triode thyratron as the sweep tube. My last homebrew (non SSTV) scope was built in '64 using a 3FP7A for my 2nd year project at Orange Coast College where I was enrolled in the Electronics Technology program.

This project is another of those that I have wanted to build for quite some time. I was lucky enough to stumble over most of the major parts to build this scope a couple of years ago at the General Dynamics amateur swapmeet. So it was more of finding the time than finding the parts.

This monitor scope was built as a matching accessory to my 6AG7/1625 100W CW xmtr (ER#61). I was primarily interested in

observing the keyed CW waveform and designed the scope accordingly. There is plenty of room in the enclosure to expand the scope's capabilities if the need arises.

The scope is built using an Easy Tech E3120B rack mount cabinet that is distributed by Alltronics. The front panel uses a standard 3-1/2" x 19" aluminum rack panel and the enclosure measures 3.25"H x 16.625"W x 9.625"D. The rear panel is 0.062" painted aluminum. The top, bottom, and side panels are painted 0.036" stamped steel. The color is a dark charcoal. The cabinet is \$45 + shpg so it was significantly cheaper than the TES line of enclosures that I used for the 6AG7/1625 xmtr and other projects. I like the TES enclosures better, but the >\$60 savings using the Easy Tech enclosure was awfully hard to ignore.



Top view. A JAN 2" magnetic shield is used to protect the 2AP1A from the pwr xfmr's magnetic field. The mounting holes for the CRT's mounting bracket are slotted to accommodate different length CRT's. The 884 sweep tube is to the right of the CRT.

The following are some of the highlights and comments about the completed monitor scope:

- \* The basic scope circuit is very close to the circuit described in the (say) 1961 ARRL Handbook. The values were selected to correspond with the 2AP1A data sheet and values on hand.

- \* The INTENSITY and FOCUS controls are AB type J and Ohmite type AB 2W linear pots. The HORIZONTAL and VERTICAL centering

controls are Clarostat 2M w/insulated shafts, a reasonable precaution since they are connected directly to the 755V supply. If you use AB type J and/or Ohmite type AB pots, check them for noise BEFORE you mount them and wire the scope. Three out of four of mine were "noisy". I pulled the backs off all four and cleaned them with contact cleaner before putting them back together.

- \* A Millen 80072 2" bezel is used to support the CRT at the front panel. Don't use the supplied template to locate the holes for the bezel - it's not accurate enough. The 2-9/32" hole for the bezel was initially punched with a Greenlee 2-1/4" chassis punch and then enlarged with a file.

- \* A JAN 2" magnetic shield is used to minimize the effects of the power xfmr's magnetic field. The clamp for the CRT's base was removed from the rear of the shield because the 2AP1 was too short for this particular shield. Without the shield, the pwr xfmr would have to be moved as far away from the CRT as possible and then oriented for minimum distortion of the trace. My layout requires the shield. Some designs have successfully (?) mounted the xfmr behind the CRT's socket without using a shield. If you decide to use a 2AP1 in your monitor, early, metal-based 2AP1's with their 1.7" base dia., will NOT fit through the smaller 1.5" dia. at the rear of the JAN shield. What a surprise!

- \* The 2AP1's 11-pin small shell magnal steatite socket is mounted on an L-shaped aluminum bracket. The 1-19/32" hole for the CRT's socket was initially punched with a Greenlee 1-1/2" chassis punch and then enlarged with a file. Since the overall lengths of 2AP1/2AP1A CRT's are different (0.25" between four of mine), I slotted the mounting holes in the bracket. The socket is an Amphenol 49-SS11L. Don't rigidly mount the socket - let it "float". Install the socket with the keyway slightly offset, pin #1 at the bottom. The final alignment of the trace is done by rotating the CRT in its socket.

- \* I used the same technique finishing the front panel as my 6AG7/1625 xmtr. The front panel was painted a bright yellow over the dark charcoal gray. Black dri-transfer lettering was used to label the front panel.

- \* Most of the front panel hardware is from Radio Shack. The SPST and SPDT toggle switches came from their 275-322 assortment. The knobs are four 274-415 black hexagonal 3/4" dia. w/aluminum inserts and two of the larger 274-416 1" dia. The incandescent pilot light uses a 272-340 holder with a 272-1142 6V 100mA bulb (E-5 base). I reduced the bulb's current a bit with a 22Ω 1W series resistor - it was too bright without it. An added advantage of the 22Ω series resistor is that it increases the life of the bulb by limiting the inrush current when the bulb is first turned on.

- \* The power supply uses a standard full-wave voltage quadrupler. The power transformer is a Thordarson 26R38 with 125V @ 50mA and 6.3V @ 2A secondaries. The secondaries' almost 19W capacity should be sufficient to handle future circuit expansions. The LV and HV measures 373V and 755V respectively at nominal 120VAC line-voltage. The power supply components are mounted on a single-sided 2-1/4" x 4-1/4" PCB.

- \* The HV divider resistors are 1W and mounted to the front panel



on 6-32 phenolic standoffs. The 180K and 0.1uf capacitor at the "top" of the HV divider filters out the ripple from the power supply - there is significant trace ripple without this RC.

\* The horizontal sweep uses a type 884 triode thyratron. This was a very popular sweep tube in early oscilloscopes. I spent a few weeks looking at alternate sweep circuits before (again) selecting the 884.

\* Keeping the design as simple as possible, I originally connected the xmtr through a low value fixed capacitor. After using the monitor for a few days with the 100W xmtr, it was clear that a fixed value wasn't going to cut it. I installed a Hammarlund type MC 75uuf variable on the rear panel and insulated it from the chassis with a scrap piece of PC board. A 3/4" hole provides clearance for the variable's shaft and hardware. This value is just about right for 100W class xmtrs. The vertical height of the xmtr's envelope is adjustable from about 0.4" to 2".

\* The monitor is connected to the xmtr using a T-connector in the RF line.

The following are some comments about the 884 horizontal sweep:

\* I have used the 884 as a stand-alone sweep circuit - no additional horizontal amplifier stage is required. I wanted a very simple horizontal sweep that would still sync to an external signal.

\* The horizontal sweep can be synced to an internal 60Hz (6.3VAC) source or an EXTERNAL INPUT can be selected with a front panel toggle switch.

\* The sawtooth amplitude vs grid voltage can be determined from the table below or the following formula can be used to estimate the sawtooth amplitudes for grid voltages more negative than -5V:

$$E\text{-sawtooth P-P} = (E\text{-grid} \times -11.9) - 40$$

E-grid	E-sawtooth	E-grid	E-sawtooth	E-grid	E-sawtooth
-3V	5V	-9V	66V	-15V	136V
-4V	12V	-10V	76V	-16V	150V
-5V	21V	-11V	88V	-17V	160V
-6V	32V	-12V	100V	-18V	175V
-7V	42V	-13V	112V	-19V	185V
-8V	53V	-14V	126V	-20V	196V

\* A grid voltage of -18V was selected. A 1N4746B 1W 18V zener diode is used in the 884's cathode with a 130K 2W resistor returned to the LV supply. The zener diode guarantees a stable grid voltage which guarantees a stable sawtooth waveform. The sawtooth's amplitude is very sensitive to changes in grid voltage. The standard resistive divider to the unregulated LV or HV supply is not stable enough.

\* The output of the 884 provides a 175V sawtooth to the 2AP1's horizontal deflection plate and provides a horizontal trace width

of 1.4" at an A2 voltage of 600V. Trace widths vary from 1.2" to 1.7" in four 2AP1/2AP1A's tested.

\* The 884's current limiting resistor in the plate is increased to 820 ohms to limit the peak-cathode currents < 300mA at these higher sawtooth amplitudes.

\* The amplitude of the sawtooth is unaffected by changes in 884 plate voltage. Changes in plate voltages will change the sawtooth's period. The following table demonstrates how the sawtooth's period changes vs plate voltage with a fixed RC (1M, 0.1uF):

HV	E-grid	E-sawtooth	Period
150V	-10V	76V	98mS
200V	-10V	76V	62mS
250V	-10V	76V	45mS
300V	-10V	76V	34mS
350V	-10V	76V	29mS

The larger the difference between the 884's plate voltage and the sawtooth's amplitude, the more linear the sawtooth will be.

\* The 884's timing resistor and SWEEP control is returned to the 755V supply to improve the linearity of the sawtooth. The SWEEP control is an AB type J 2W linear pot insulated from the front panel using a fiber shoulder and flat washer. The RC timing components have been selected to provide two overlapping sweep ranges: 10-100 Hz (LO) and 50-500 Hz (HI).

\* The sawtooth's linearity is slightly degraded by the 0.2uF horizontal coupling capacitor at low sweep speeds. The coupling cap is a dual-section bathtub type capacitor that is wired in parallel.

\* A 1N5956B 200V 1.5W zener diode is connected from the plate to the cathode to clamp the 884's plate voltage to approximately 218V when the power is first turned on. Once the 884 warms up, the selected 175V firing point is well below the zener's knee. Without the zener, the timing capacitor would charge to the value of the HV supply before the 884 had a chance to warm-up.

\* The sweep circuitry components are mounted on a single-sided 3" x 4" PCB.

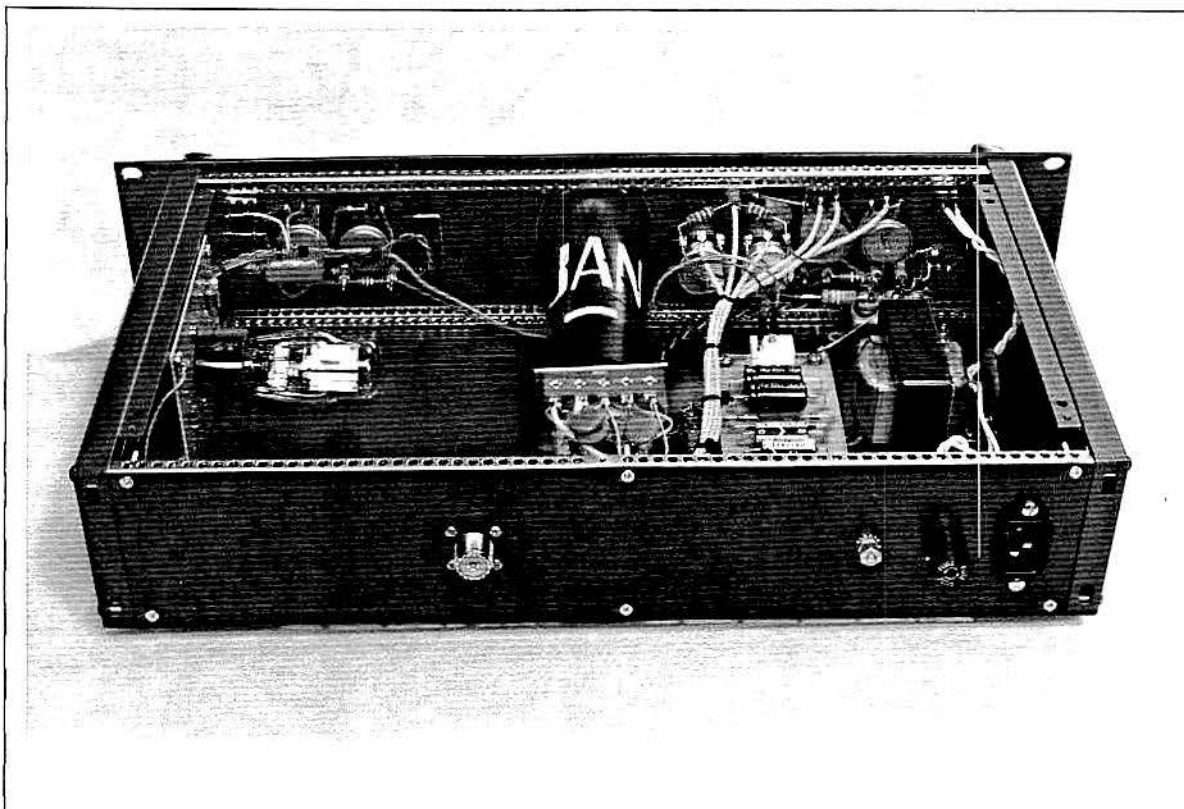
I had a particular goal in the design of this monitor - to work nearly as well as my Kenwood SM-220 as a CW monitor scope. I have used the SM-220 for nearly five years now and find it invaluable as an in-line monitor in evaluating the keying characteristics and envelopes of CW and AM xmtrs. Not all my expectations were met with this monitor:

\* The biggest problem is that I couldn't set the monitor on top of the xmtr as planned. The magnetic field from the xmtr's plate xfmr caused objectionable trace ripple during transmit. It appears that the JAN shield isn't "bullet proof".

\* I wanted to restrict the size of the scope to a 3-1/2" panel height and that pretty well dictated the use of a 2" CRT, bezel,

and shield. The 2AP1 is certainly adequate, but the differences between the 2" and SM-220's 3" CRT lean toward the 3" CRT. If panel height isn't a "problem", use the 3" CRT.

\* The end-to-end fine-line focusing of the 2AP1 leaves a bit to be desired, although the overall focus of the keyed waveform is acceptable. The end-to-end focusing "problem" is probably a geometry "problem" with the 2AP1 - remember, this CRT is 50 years old.



Rear view of the monitor.

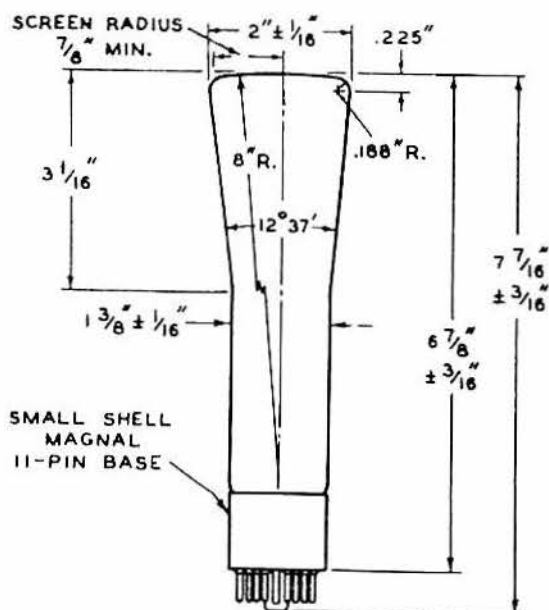
Other than these objections, the monitor works pretty well. At low sweep speeds, you can easily evaluate the rise and fall times of the keyed waveform. At higher sweep speeds, you can use the 60Hz sync to verify the presence of 60Hz or 120Hz ripple on the envelope. The poorer linearity of the sweep at low speeds is noticeable, but not objectionable.

This article was written 5/94.

#### Selected References:

1. RCA 2AP1A characteristics, July 1, 1945.
2. RCA 884 characteristics, December 15, 1944 and January 4, 1945.
3. "Encyclopedia on Cathode-Ray Oscilloscopes and Their Uses", John F. Rider and Seymour D. Uslan, 1950.
4. "Voltage Multipliers", Jack Althouse, K6NY, QST, Oct.'71, pgs. 29-33.
5. "Design of Cathode-Ray Tube Circuits", Walter Knoop, ex-W9KHG,

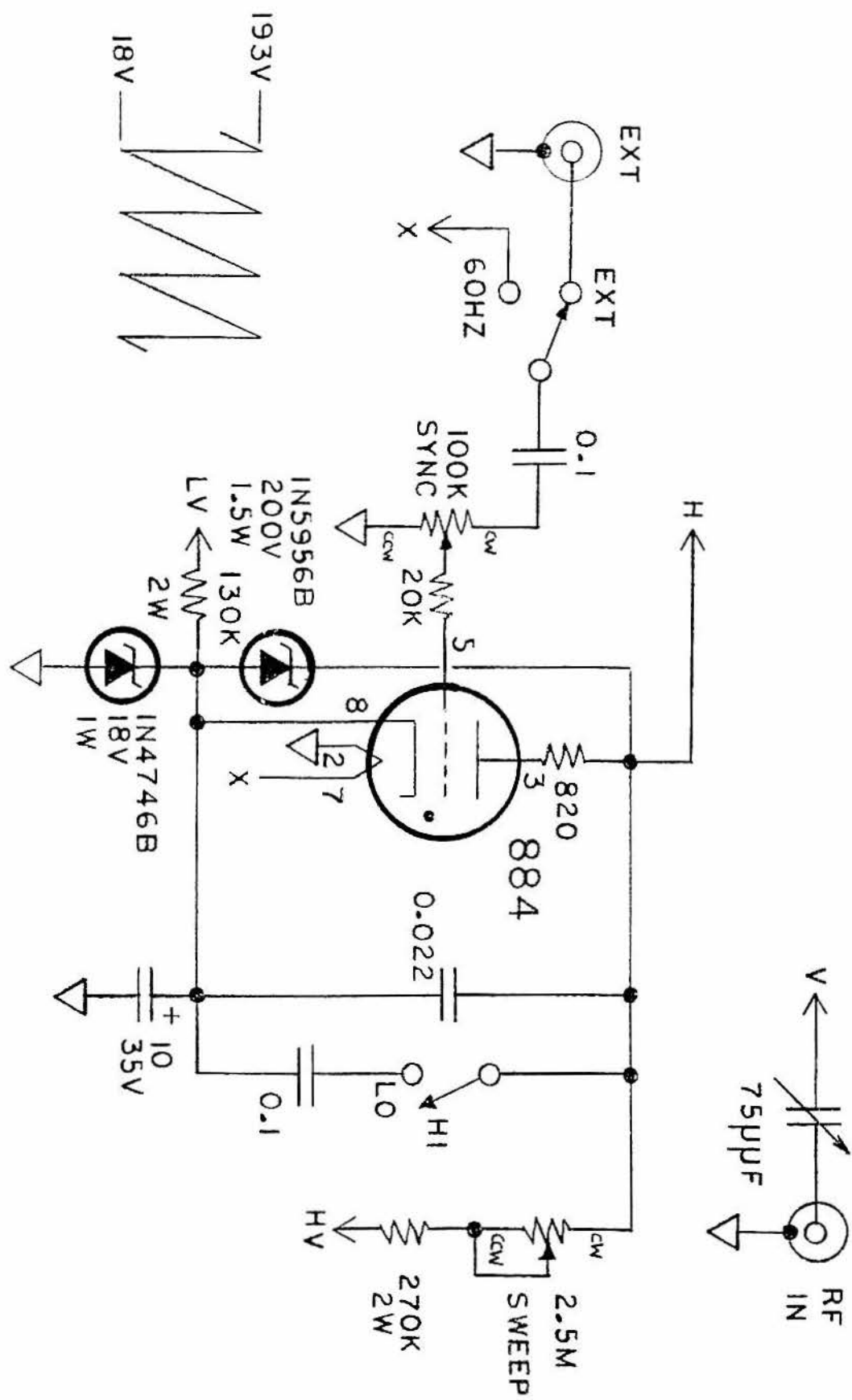
- QST, Dec.'46, pgs. 45-50, 160.
6. "A Scope For the Ham Shack", Robert Weitbrecht, W6NRM, QST, Feb.'48, pgs. 51-57, 126.
  7. "How's My Modulation?", J.L.Hollis, W0JET, QST, Sep.'48, pgs. 49-51.
  8. "Electronic Instrumentation - Cathode-Ray Tubes as Metering Devices", M.H.Dunbrack, W1BHD, and R.A.Bradbury, W1NUQ, QST, Feb.'51, pgs. 16-17.
  9. "Cheaper and Better Phone Monitoring", Basil C. Barbee, W5FPJ, QST, Aug.'52 QST, pgs. 31-33, 118.
  10. "What's the Percentage", William I. Orr, W6SAI, CQ Magazine, Apr.'53, pgs. 33-37.
  11. "The Hamscope - Monitors Your AM or SSB Transmitter", GE Ham News, Sep.-Oct.'56 (part of the 1st Edition GE Ham News Sideband Handbook, pgs. VI-5 thru VI-13).
  12. "Oscilloscope Circuit", Hints and Kinks, QST, Jan.'60, pg. 55.
  13. "The Radio Handbook", William I. Orr, W6SAI, Sixteenth Edition, '62, pgs. 750-751.
  14. "Sawtooth Sweep For Modulation Monitor Scope", Vernon Trexler, CQ Magazine, Feb.'61, pgs. 34-35.
  15. "An Oscilloscope Monitoring Adaptor", David T. Geiser, WA2ANU, CQ Magazine, Nov.'63, pgs. 76-77, 119.
  16. "The Radio Communication Handbook", Radio Society of Great Britain, Fourth Edition, '68, pgs. 19.37-19.42.
  17. "Test Equipment For The Radio Amateur", Radio Society of Great Britain, Second Edition, '78, pgs. 9.1-9.8.
  18. "Watch Your Modulation! Use a 'Scope", John Staples, W6BM, Electric Radio, Mar.'90, issue #11, pgs. 12-16.



2AP1-A







- - - PACKAGING GEAR TO SURVIVE UPS - - -

How many times have you bought a piece of gear, had it shipped UPS, and then had tears in your eyes as you unpacked it and saw the "shipping damage"? I have had this happen to me several times in the last two years - more than enough to make me uncomfortable about buying gear that needs to be shipped via UPS.

In spite of UPS' poor reputation, ALL of the units that arrived via UPS that were damaged in shipment were NOT the fault of UPS. While it is true that the damage occurred during shipping and/or handling, the damage could have been prevented by "proper" packaging.

Like beauty, proper packaging is "in the eye of the beholder" and is only "skin deep" - it's what's inside that counts. In shipping electronic gear via UPS, you have to plan for worst case shipping/handling scenarios. To that end, I will usually use a double-box packaging technique. The following is a thumbnail sketch of my double-box technique:

- \* Place the unit to be shipped into a plastic bag and tape it shut. This will keep the shipping material from getting into the unit. Make sure that the AC line cord won't scratch the cabinet or front panel - keep it outside the plastic bag if possible.

- \* Tightly wrap the unit in several layers of foam or large bubble wrap. Wrap in all three directions.

- \* Place the wrapped unit inside the inner box using a four inch clearance all the way around, top and bottom. Using peanuts, center the unit in the inner box. Pack the peanuts tightly. When you close and tape the inner box, the box should bulge slightly. This will minimize the unit moving around/changing location in the inner box.

- \* Place the inner box inside the outer box using four to five inches clearance all the way around, top and bottom. Using peanuts, pack it the same way you packed the inner box. When you close the box, it should bulge slightly. The box shouldn't be too easy to tape or it probably doesn't have enough peanuts. Use several layers of tape top and bottom to seal the box. Tape the edges.

Don't limit the above technique to "equipment". I received a B&W Model 850 Pi-Network Assy absolutely destroyed by UPS. It was loosely packed in a relatively small box with crushed paper packaging. Recently, 1625's arrived broken using the same (poor) packaging technique.

Additional Notes:

- \* DON'T USE PAPER AS A PACKING MATERIAL! It compresses and will allow the unit to move around inside the box - bad news if there is a heavy power transformer on a thin gauge aluminum chassis.

- \* Pack the unit as tightly as possible. The box should bulge slightly after taping. Tight packaging will minimize migration.

- \* Keep the unit away from the sides of the box. Expect the outer box to be penetrated and/or dropped. Generally speaking, the

larger and heavier the unit, the more clearance required inside. If you're not sure, increase the clearance. The clearances I stated above are extremely arbitrary - use what works for you - but expect worst-case UPS handling situations.

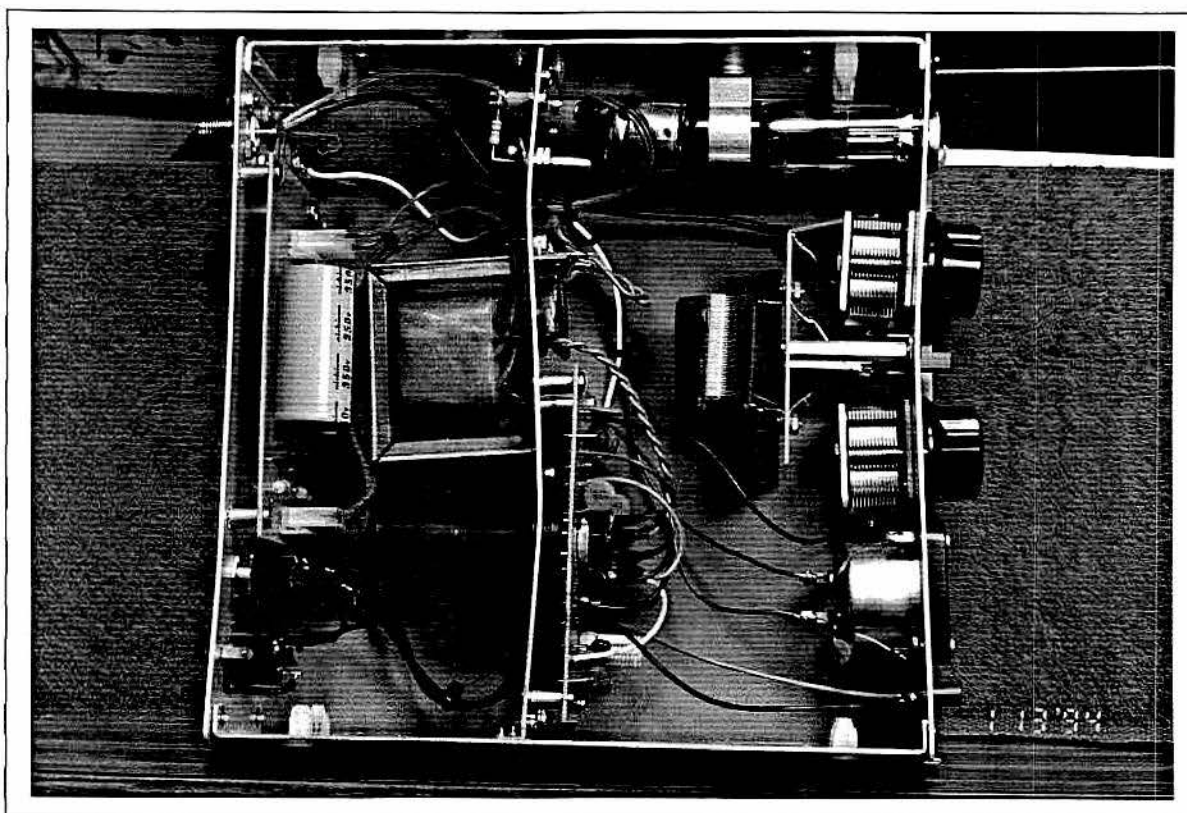
\* If you find yourself regularly shipping either parts or units, then save the incoming boxes and packaging materials. You can save a small fortune saving this stuff. If the boxes are damaged, discard them. If you're not sure, discard them - just keep the "good" stuff.

\* Barry/ER has a good suggestion. If you're using peanuts, put them in smaller plastic grocery bags. The bags "will prevent a mess when the gear is unpacked and may also be beneficial in preventing migration of the gear around the box."

This article was written 10/93 and originally appeared in Electric Radio, Dec.'93, issue #56, "Packaging Gear to Survive UPS", pg. 18.

#### Selected References:

1. "Packing Radio sets for Shipping", Walt Huthens, KJ4KV, Electric Radio, Sep.'89, issue #5, pg. 26.



Top view of the 6AG7/6E5 80/40M QRP CW xmtr after being shipped from California to Alabama and back again. Several connections snapped and all three panels are bent. This xmtr was conservatively double-boxed for shipment. In spite of the damage, this xmtr was >99% repairable.



- - - PACKAGING GEAR TO SURVIVE UPS REVISITED - - -

I shipped my Ocean Hopper and 6AG7/6E5 80/40M QRP xmtr (ER#56, pgs. 24-27) to Dave Ingram, K4TWJ, for his WORLD OF IDEAS column "Homebrew Classics From the Fifties - Part I,II" in the February and March '94 issues of CQ. It was shipped to Dave in Alabama via UPS. I double-boxed packaged the Ocean Hopper and xmtr in separate boxes. I used a 16" x 18" x 28" outer box, over 4.6 cubic feet, and lots of peanuts. I also used foam in the inner boxes. All boxes were very tightly boxed and taped for shipment. I asked Dave to use the same packaging technique in returning the gear, and he did. The outer box was penetrated on the trip home but there was no damage to either of the inner boxes - no marks.

The Ocean Hopper successfully survived both trips. As can be seen from the photograph on pg. 132, the xmtr did not. If you look carefully at the CQ photo of the xmtr in the March '94 issue, pg. 113, you can see that the front-, rear-, and internal sub-panels are already slightly bowed. Some of the damage occurred on the way to Alabama!

All three panels are relatively soft aluminum and only supported at the ends. The inner sub-panel has the heaviest component on it, the xfmr, and it suffered the worst damage. I think that the heavy components on poorly supported panels is an "accident looking for a place to happen" when shipping UPS. In light of this "experiment", I'm not sure how I could ship this xmtr via UPS and guarantee that it gets from point A to B intact.

The design of the Ten-Tec CONSTRUCTO SERIES enclosures does not support the panel(s) at their mid-point. From a construction point of view, this isn't a problem. It only becomes a problem when you ship a completed project with sufficient weight attached to the panel(s). Adding support at the panels mid-point may be sufficient in making it "shippable". Incidentally, the xmtr was +99% repairable. The same soft aluminum panels that made it so easy to flex and bend during shipment, also made it relatively easy to repair.

This phenomenon may also explain why I've seen UPS damage with kits. They are originally shipped flat and unassembled. Much of the sheet metal is light gauge aluminum. Put it all together and it ships completely different!

Dave's comment in a recent letter says a lot, (the) "Ocean Hopper was packed to survive anything. I thought it was an overkill. Now looking at 6AG7 tx, I think you did right!"

So before you ship that piece of homebrew gear, make sure that its mechanical design/construction can survive UPS. Mine didn't and it wasn't UPS' fault or the packaging.

This article was written 3/94.

- - - MY LAST (?) HEATHKIT - - -

What do you do during a cold, rainy, overcast New Years holiday weekend? How about building my last (?) Heathkit! But first, a little background.

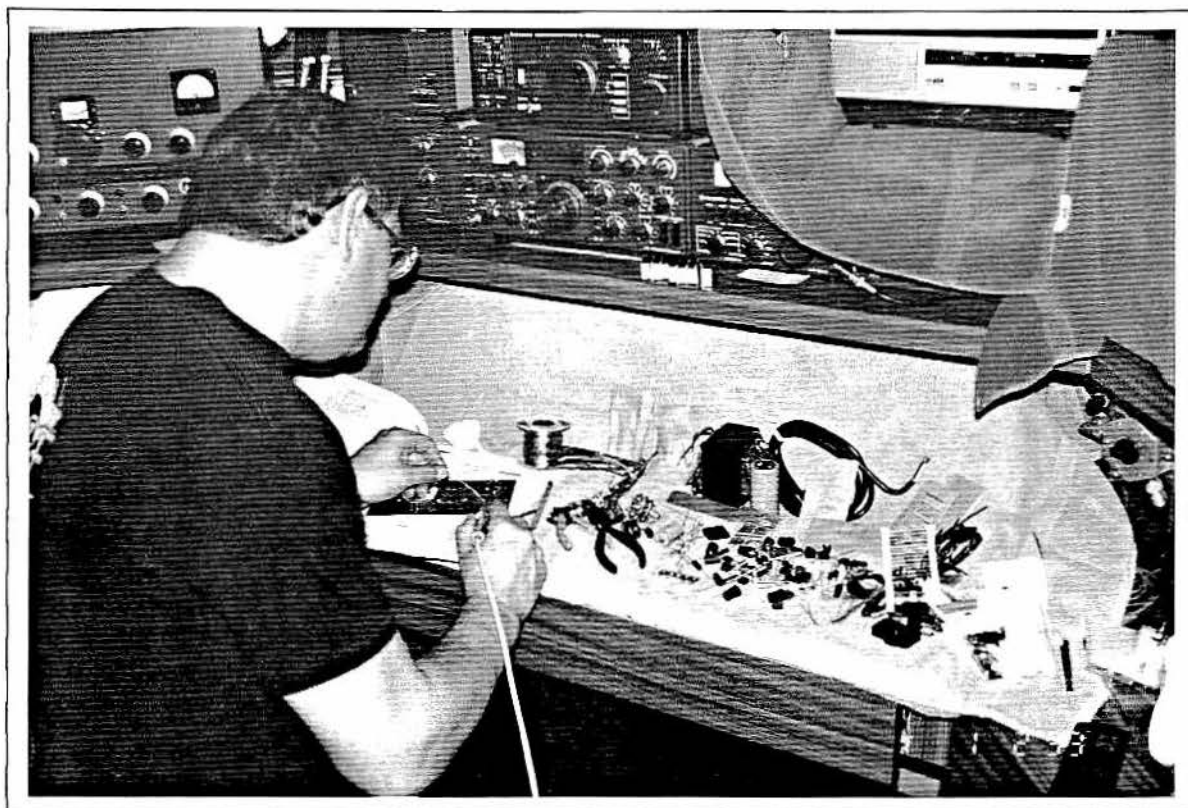
My wife Judy and I were running errands in Anaheim a few years ago and I (finally) decided to stop by the Heath Center on Ball Road to buy the Heath IP-2718 Triple Output Power Supply. I had been "dragging my feet" for months buying this kit. I thought I might do better at the local amateur swapmeets but I never found anything suitable in the IP-2718's price class (\$140). I was really surprised when we drove up to the Heath Center and it was "closed" at 1PM. I didn't find out until several months later that Heathkits were history. I don't recall any "warning" from Heath - no "going out of business sale" flyers or supplements. Their Winter 1991 catalog was disappointing with their concentration on education (16 pgs.) and home automation (28 pg. insert). Amateur radio was limited to 9 pages with 19 kits and lots of "private label" equipment (SBS-1400 from Yaesu, HK-232 from AEA, the SB-1000 from Ameritron, etc.). I suppose in retrospect, the writing was on the wall. The Winter 1963 catalog featured 31 kits and the 1969 catalog featured 42 kits that were amateur radio related. I really never once considered "life without Heathkits"!

My first kit was a Knight kit Ocean Hopper regenerative receiver in 1958 (ER#42). My second kit was a Heath CT-1 In-Circuit Capaci-Tester that I built in 1959. I bought it at a Heath store in Santa Barbara for \$7.95. During the next 34 years, I built twenty Heath kits (5 of which I still have). They ranged from the simpler HN-31 Cantenna and HD-1416A Code Practice Oscillator to the IO-14 5" Scope and SB-200 Linear Amplifier to the harder HW-101 Transceiver and GR-900 Color TV. I still have seventeen Heath kits and have owned\traded\destroyed\cannibalized twenty more. Heath kits have **very significantly influenced** not only my amateur radio hobby, but more importantly, my career in industrial electronics.

Imagine my surprise when walking through the "old" General Dynamics swapmeet early last year when I found an original Heath IP-2718 Triple Output Power Supply still in kit form. The box had been opened but the contents had not been removed or disturbed - Heath "addicts" know when a kit box is original! I was pretty confident that all the parts still there. I bought my last (?) Heath kit for \$40!

I decided to build the IP-2718 over the New Years holiday. I was very tempted to leave it in kit form as a collectible but I gave in to the urge to build my last Heathkit. It took me 11 hours to assemble, checkout, and calibrate the IP-2718. I had forgotten how much "fun" it is to build a kit. It is still a "kick" to see something you have built "come to life" when the power is applied - as you give it the "smoke test" - even if I did "cheat" and

use a variac. The "kick" from building a kit is not that much different from that of building a completely homebrew project from scratch.



Building my last (?) Heathkit, a model IP-2718 Triple-Output Power Supply.

I'm really going to miss building Heathkits. For you Heath "addicts", **HEATH NOSTALGIA** by Terry Perdue/K8TP is required reading. The title page says:

"A brief history of the Heath Company of Benton Harbor, Michigan - with fond memories of and by those who were responsible for the Heathkit name becoming world famous."

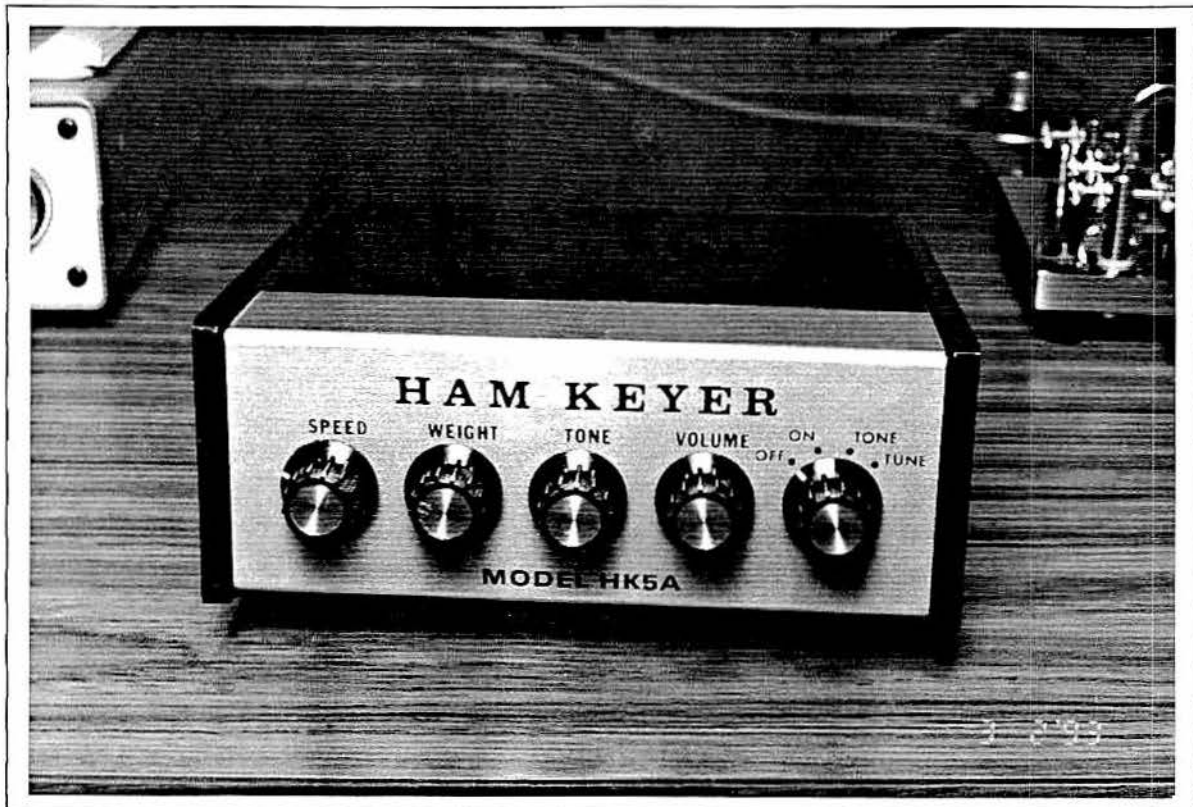
This article was written 1/93 and originally appeared in *Electric Radio*, Mar.'93, issue #47, "My Last (?) Heathkit", pg. 23.

**Selected References:**

1. "The Last Heathkit", Michael White, N4PDY, *QST*, Oct.'92, pgs. 74-75.
2. "My Last Heathkit", Steven H. Leibson, *EDN*, April 15, '93, pg. LL5.

- - - RECYCLED HK-5A KEYER - - -

Not all my projects are built from scratch. Recently, when I wanted to build a matching keyer for my 6AG7/6E5 80/40M QRP transmitter, the logical choice was to repackage a homebrew keyer that I built in 1975. It wouldn't fit, however, in a reasonably sized Ten Tec CONSTRUCTO SERIES enclosure. As a result, I decided to repackage a model HK-5A keyer that I have been using since 1989. I have seen these for sale from \$10-\$20 at the local TRW swapmeet.



Front view of the unmodified HK-5A keyer.

The HK-5A was sold by Ham Radio Center and could have been an OEM version of the MFJ M52A (circa '79). The HK-5A uses a Curtis 8044 IC and the schematic is very similar to the 8044 keyer on pg. 11-14 in the 1979 ARRL Handbook. Compare the simplified HK-5A schematic with the one in the Handbook. The original HK-5A is powered by 4 C-cells, has a built-in speaker, and will key both grid-block and cathode-keyed transmitters. The cathode-keyed input (DIRECT) uses a 300V TO-92 MPSA42 transistor & will handle 100 mA. It has worked very nicely with my 6AG7/6E5 and 6AG7/1625 xmtrs. The quiescent/key-up battery drain of the HK-5A is very low so I hardly ever worry about turning it off.

This entire project took about 4 hours, start to finish. The following are some of the highlights and comments of the completed



and recycled HK-5A keyer:

- \* I repackaged the HK-5A into a Ten Tec CONSTRUCTO SERIES 2-1/2" x 6" x 5" BU625 enclosure to match the 6AG7/6E5 80/40M QRP CW xmtr.

- \* I discarded the original speaker and installed a Mouser 3" square 8 $\Omega$  speaker P/N 253-2130. The speaker was mounted on the bottom and a 2-1/4" hole was punched using a Greenlee chassis punch.

- \* The original quad C-cell battery holder was discarded and replaced with two Mouser 12BH221 dual C-cell battery holders mounted against the enclosure sides on either side of the speaker.

- \* After the holes were drilled in the enclosure, the entire HK-5A assembly was removed from the old case and installed in the new enclosure. The only "new" wiring required was to the new speaker and battery holders.

- \* The knobs were changed to match the xmtr.

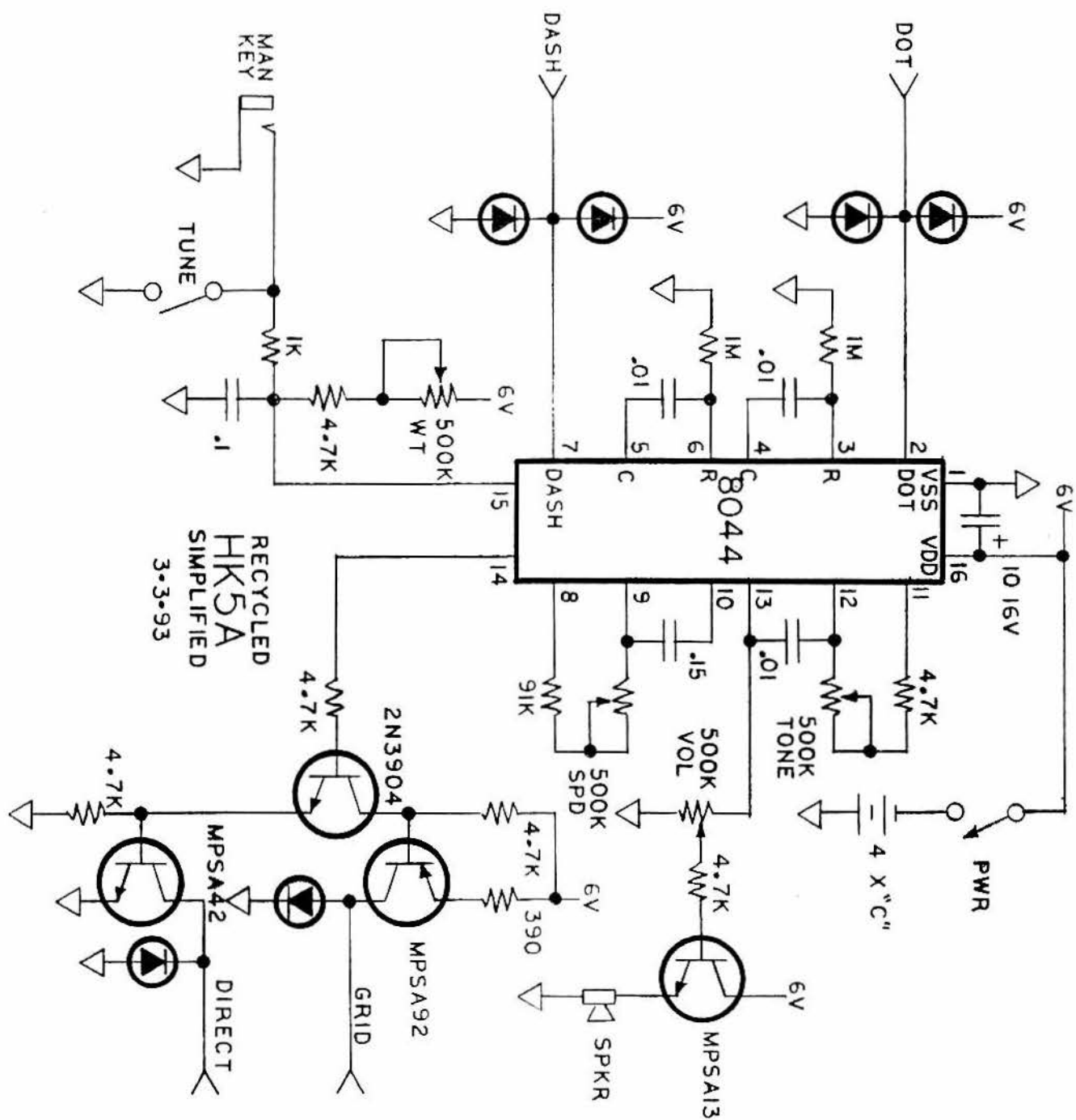


Front view of the recycled HK-5A keyer and the 6AG7/6E5 80/40 QRP CW xmtr. Keyer was packaged into a matching Ten-Tec BU625 CONSTRUCTO SERIES enclosure. A larger 3" speaker was used.

This article was written 4/93.

#### Selected References:

2. "A Single-IC Keyer", The Radio Amateur's Handbook, ARRL, 56th Edition, 1979, pgs. 11-11 and 11-14.
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